

FUSION ADVISORY PANEL

MEETING

CONVENED BY THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND PRODUCTION

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-SEVENTH CONGRESS

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JUNE 29, 1981

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(III)

FUSION ADVISORY PANEL

MONDAY, JUNE 29, 1981

HOUSE OF REPRESENTATIVES, COMMITTEE ON SCIENCE AND
TECHNOLOGY, SUBCOMMITTEE ON ENERGY RESEARCH AND
PRODUCTION,

Washington, D.C.

The subcommittee met, pursuant to call, at 12:30 p.m., in room 2325, Rayburn House Office Building, Leonard F. C. Reichle (chairman of the Fusion Advisory Panel) presiding.

[Letter of welcome from the Hon. Marilyn L. Bouquard follows:]

MAR-LYN LLOYD BOUQUARD
30 DISTRICT, TENNESSEE

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Congress of the United States
House of Representatives
Washington, D.C. 20515

June 26, 1981

2234 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, D.C. 20515
TELEPHONE: (202) 225-3271

230 JAY SOLOMON FEDERAL OFFICE BUILDING
CHATTANOOGA, TENNESSEE 37401
TELEPHONE: (615) 267-0108

1211 FEDERAL OFFICE BUILDING
CHATTANOOGA, TENNESSEE 37401
TELEPHONE: (615) 376-1977

Mr. Leonard F. C. Reichle
Executive Vice President
EBASCO Services, Inc.
Two World Trade Center
New York, N.Y. 10048

Dear Len:

It is with a great deal of pleasure that I welcome the Advisory Panel back to the "Hill". The facts of political life have prevented me from attending today's panel meeting but I am genuinely looking forward to attending future meetings.

The importance of the Panel at this stage of the fusion program cannot be overstated. To advance fusion into the technology development phase and involve industry in its most effective form will be a non-trivial task, but it must be done. In this regard, the Center for Fusion Engineering appears to be one mechanism for involving industry and its establishment is an issue of central importance to the fusion community. It is also an issue which Congress can deal with inside a very tight FY 1982 budget. I am sure that many perspectives on the CFE will be gained through the presentations to the Panel, and these perspectives, weighed by the Panel's experience, are what I wish to have presented to the Subcommittee.

I should like to charge you and the Panel with the task of preparing a brief report for the Subcommittee covering the essential points brought forth in this Panel meeting. In particular, I am concerned with questions such as:

Whether the CFE is, in fact, needed to bring about real industrial involvement? Or is it only one of many possible avenues?

If one does not introduce a CFE, what mechanism is available to bring industry into the management end of the fusion program in a way which will allow industry and utility input into DOE policy and planning?

If the CFE is desirable, what appears to be the most suitable and workable management scheme? How long will it take to implement such a scheme and at what cost?

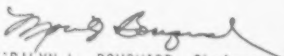
Should the Center's goals be narrow or broad based?

Clearly, one could produce an almost endless list, but I will trust the Panel to address and include in the report only the points they believe to be the most relevant.

I know this task will not be easy but if it is to be useful to the Congress it must be finalized within the next few weeks. Please extend my gratitude and personal best wishes to our Panel members and to those who are presenting their views on the CFE.

Although one always views adversity as moving too fast and progress as moving too slow, I wish to assure the Panel that their work will eventually be rewarded in a strong viable fusion program. Finally, I would like it to be known that my intent is to see a line item for the Fusion Engineering Device no later than the FY 1984 budget, and the CFE, if we are to have one and if it is to function as a viable entity, must be put in place in FY 1982. Please help us in Congress to assess this issue. I wish you all the best of luck.

Sincerely,



MYRLYN L. BOUQUARD, Chairman
Subcommittee on Energy Research
and Production.

Mr. REICHLE. Will the panel meeting please come to order.

I am Len Reichle, executive vice president of EBASCO Services, Inc., in New York, and have the honor and the pleasure of serving as chairman of this Panel.

I would like to mention at the beginning that this is not a congressional hearing, rather it is a meeting of the Advisory Panel on Fusion Energy to the Energy Research and Production Subcommittee of the House Science and Technology Committee. Today we will receive presentations on the topic of a Center for Fusion Engineering.

Before we proceed, I would like to ask other Panel members, starting at the far end of the Panel table here, to introduce themselves and then we will take the next step.

Dr. DAVIDSON. Ron Davidson, MIT.

Dr. ROSENTHAL. Murray Rosenthal, Oak Ridge National Laboratory.

Mr. SPENCER. Dwain Spencer, EPRI.

Dr. EVANS. Ersel Evans, Westinghouse Hanford Co.

Mr. MCCORMACK. Mike McCormack, former Member of Congress.

Dr. FURTH. Harold Furth, Princeton Plasma Physics Laboratory.

Mr. BLATTNER. Cal Blattner, McDonnell Douglas Corp.

Mr. CAIRNS. Bryan Cairns, Boeing Engineering & Construction.

Dr. FOWLER. Ken Fowler, Lawrence Livermore Laboratory.

Dr. OHKAWA. Tihiro Ohkawa, General Atomic Co.

Mr. REICHLE. Next I would like to read into the record and for the information of everyone present a letter addressed to me from Congresswoman Marilyn Bouquard, chairman of the Subcommittee on Energy Research and Production, a letter dated June 26.

DEAR LEN: It is with a great deal of pleasure that I welcome the Advisory Panel back to the "Hill". The facts of political life have prevented me from attending today's panel meeting but I am genuinely looking forward to attending future meetings.

The importance of the Panel at this stage of the fusion program cannot be overstated. To advance fusion into the technology development phase and involve industry in its most effective form will be a non-trivial task, but it must be done. In this regard, the Center for Fusion Engineering appears to be one mechanism for involving industry and its establishment is an issue of central importance to the fusion community. It is also an issue which Congress can deal with inside a very tight fiscal year 1982 budget. I am sure that many perspectives on the CFE will be gained through the presentations to the Panel, and these perspectives, weighed by the Panel's experience, are what I wish to have presented to the Subcommittee.

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If the CFE is desirable, what appears to be the most suitable and workable management scheme? How long will it take to implement such a scheme and at what cost?

Should the Center's goals be narrow or broad based?

Clearly, one could produce an almost endless list, but I will trust the Panel to address and include in the report only the points they believe to be the most relevant.

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As to procedure for this afternoon's hearing, we have arranged the people who have expressed an interest in making a presentation into three panels. At the end of the second panel, we will have a 10-minute recess. We suggest that both presenters in the first panel finish their presentations before questions are asked. Similarly, after all presentations in each of the next two panels have been made, we will entertain questions and comments.

Only members on the Advisory Panel will be permitted to ask questions and make comments to the presenters. Similarly the presenters will be addressing their comments to Panel members.

Now, before we start, I would like Dr. Allan Mense to put on the screen a summary of two of the questions that were raised to Mr. James Edwards, Secretary of Energy.

Why don't you read the questions and the answers.

Dr. MENSE. We want to show you two questions that were asked of Secretary Edwards when he appeared before the House Science and Technology Committee this year, and the corresponding answers to those questions.

The first question is: Is the Department changing its view that the magnetic fusion program is technically ready to move into the engineering development phase? If so, please explain the basis for this change.

Secretary Edwards' answer was:

The technical readiness of the magnetic fusion program to move ahead into the engineering development phase is not in question. The technical readiness has been uniformly judged to be adequate by four prestigious review groups in 1980.

He goes on to name the Energy Research Advisory Board, the Fusion Advisory Panel to the House Science and Technology Committee's Energy Research and Production Subcommittee, the International Fusion Research Council, and the Atomic Industrial Forum.

As a follow on question to Secretary Edwards, he was then asked: If there is no technical reason for retrenching from the aggressive approach required by the Magnetic Fusion Energy Engineering Act of 1980 [Public Law 96-386], then please explain whether or not you believe that the fusion program fits within President Reagan's guidelines emphasizing long-term, high-risk, and high-payoff research in terms of funding priority.

Secretary Edwards' answer was:

Yes, I believe that fusion represents the type of research and development activity that requires Federal support. It is too long-range for significant private investment; the chances of success are not yet certain; the investment required is large; society as a whole will benefit; and the potential benefits are very large. In the formulation of its fiscal year 1983 budget, the new administration will very carefully consider all of the factors related to the timing and pace of the fusion program and, in particular, the commitment to a multiyear, billion-dollar investment such as the Fusion Engineering Device.

Mr. REICHLE. I think we can see from the overwhelming support given by both Houses of Congress last year to the McCormack bill, which became an act, and to the Secretary of Energy's answers to the questions that were just read to you, there should be no reluctance about our moving ahead on a Center for Fusion Engineering.

The question before us is how should such a Center be established and what are the pluses and the minuses of different ways of going about it?

Our first panel member is Steve Dean, president of the Fusion Power Associates. Steve.

STATEMENTS OF DR. STEPHEN O. DEAN, PRESIDENT, FUSION POWER ASSOCIATES, GAITHERSBURG, MD., AND SIDNEY LAW, DIRECTOR OF RESEARCH, NORTHEAST UTILITIES, HARTFORD, CONN., REPRESENTING THE ATOMIC INDUSTRIAL FORUM COMMITTEE ON FUSION

STATEMENT OF DR. STEPHEN O. DEAN

Dr. DEAN. Thank you, Len. It is a pleasure to be here.

Fusion Power Associates, as most of you know, is a nonprofit, tax-exempt public benefit corporation dedicated to the expeditious development of fusion as a practical energy source for future generations. We presently have, as listed in attachment A, 25 members and 14 affiliates—primarily high-technology industries and electric utilities.

Contrary to some popular beliefs, Fusion Power Associates is not a lobbying organization, nor are we an industrial trade association, as is the Atomic Industrial Forum. Rather, our purpose is to benefit the public by assisting all parties, Government, national laboratories, and universities, to work together to expeditiously develop fusion for the benefit of mankind.

Fusion Power Associates directly contributed last year to the formulation of the fusion policy statements contained in the Magnetic Fusion Energy Engineering Act of 1980 [Public Law 96-386] and to the fusion report of the DOE's Energy Research Advisory Board (ERAB). Many of our members and affiliates also belong to the Atomic Industrial Forum and participated in the formulation of the AIF's study on the "Organization and Management of Fusion Engineering." We support the consensus reached in those reports; namely:

"The magnetic fusion program can, and should, embark on the next logical phase toward the goal of achieving economic feasibility of magnetic fusion. To this end a broad program of engineering experimentation and analysis should be undertaken under the aegis of a Center for Fusion Engineering [CFE]. [ERAB Report].

The DOE should establish a Center for Fusion Engineering operated by a strong, single-line management. [ERAB Report].

The concept of the Center for Fusion Engineering was proposed by ERAB with the intent of securing competitive industrial participation in the fusion program. [ERAB Report].

Further, as stated in Public Law 96-386, it is declared to be the policy of the United States to promote the broad participation of domestic industry in the national magnetic fusion program.

Finally, in the AIF report, I note the recommendation that, "Single line authority for both programmatic and contracting as-

pects of the engineering effort should be clearly vested in the Center for Fusion Engineering."

Fusion Power Associates support those positions.

These reports that I just referenced did not make explicit recommendations on the detailed nature of the organizations which should manage the Center for Fusion Engineering. The ERAB report, for example, states: "This organization could be either an industrial contractor or a national laboratory." The AIF report assumes that it would be an industry, but it states simply that "Priority attention should be directed by the Government to deciding how the Center should be organized and managed."

At this point in time, I think we are all embarked on answering the question, exactly what should be the nature of the organization which manages the center and how should it be established.

I do not have a detailed set of recommendations to present to you on this subject. Rather, I would like to establish certain basic principles for your consideration in addressing these questions.

To date, the responsibility for the fusion research program has centered in national laboratories and in universities. I might add, they have done an outstanding job over the past 30 years of bringing fusion understanding to the point it is today. But an opportunity exists now as we embark on the "engineering phase" of fusion development to add a new technical and managerial dimension, a new sense of urgency and purpose, to the fusion program.

So the first recommendation that I would make is to establish the very clear principle that the Center for Fusion Engineering should be industrially managed and that the selection of the industrial contractor should be the result of a competitive process.

The industrial sector has a strong interest in active participation in fusion development, including that of prime contractor in selected areas. DOE contracting practices, which tend to follow historically from those of the Atomic Energy Commission, do not tend to establish industry in this role.

I would recommend, as better models, the more industry-oriented contracting procedures of NASA or the DOD. There are several successful models which could be followed. One such model is the manner in which the Bettis & Knolls Laboratories were established and utilized. Although these laboratories were established under the Atomic Energy Commission, they did not follow the typical Atomic Energy Commission formula. In fact, when Admiral Rickover wanted to establish the Bettis & Knolls Laboratories, the Atomic Energy Commissioners, in fact, did not like this procedure and actually wanted to carry out the naval reactors development at the Argonne National Laboratory. So I think it is a mark of the success of the program that Admiral Rickover did not acquiesce in that desire.

However, and some of my members may not agree with me in making this point, I do believe that the Government must maintain leverage on the industrial contractor. In the case of Admiral Rickover, he had two contractors and one allowed him leverage on the other. If we establish a single Center for Fusion Engineering, we must guard against the possibility that the Government loses its leverage on the performance of this contractor. So I think the Gov-

ernment must maintain this leverage, including having the real intent to change contractors if necessary to insure performance.

I think it is important that the Center for Fusion Engineering not become another national laboratory. There is nothing wrong with the national laboratories. But if the Center for Fusion Engineering is to become another national laboratory, then it seems to me there is no reason not to simply designate one of the existing national laboratories as the Center for Fusion Engineering.

I feel that neither the Center for Fusion Engineering nor its sub-contractors should feel entitled to permanent levels of employment. Their levels of employment and their role in the program should be determined by their performance.

The Center for Fusion Engineering should be allowed, I believe, to establish industrial procurement and contracting procedures aimed at expediting technical progress, including broad powers to subcontract to other industries and organizations for subsystems development.

One of the major tragedies today of developing technology in the Department of Energy and its predecessor agencies is the multi-layers of review and approval which have been established by the DOE field offices and headquarters and subsequently, under their direction, the national laboratories.

We should make very great effort to exempt the Center for Fusion Engineering from these procedures. The Center for Fusion Engineering should stimulate the preparation of conceptual designs for power producing experimental reactors based on a variety of concepts and for a variety of applications. Appropriate national laboratories and universities should be integrated with industry into these design efforts.

It is important, I believe, that the Center for Fusion Engineering manager report to that official within DOE having responsibility for the overall management of the U.S. magnetic fusion program.

As I mentioned at the beginning, the above recommendations are not presented as exhaustive of the issues. Rather they are an attempt to set forth certain fundamental principles on which to base the establishment of an industrially led fusion engineering development effort.

Strong, knowledgeable, and creative national management will be required in DOE to insure the proper integration of the engineering thrust while continuing to nurture scientific progress in national laboratories and in universities. This is especially true because scientific progress continues to yield new and improved concepts and because the current engineering designs are not yet obviously attractive as commercial products.

Thank you.

[The prepared statement of Dr. Stephen O. Dean follows:]



FUSION POWER ASSOCIATES

2 PROFESSIONAL DRIVE, SUITE 248 • GAITHERSBURG, MARYLAND 20760

(301) 258-0545

TESTIMONY TO THE
ADVISORY PANEL ON FUSION ENERGY
ENERGY RESEARCH AND PRODUCTION SUBCOMMITTEE
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
JUNE 29, 1981
BY
STEPHEN O. DEAN
PRESIDENT
FUSION POWER ASSOCIATES

Fusion Power Associates is a non-profit, tax exempt public benefit corporation dedicated to the expeditious development of fusion as a practical energy source for future generations. We presently have, as listed in Attachment A, 25 members and 14 affiliates -- primarily high technology industries and electric utilities.

Fusion Power Associates contributed directly to the formulation of the fusion policy statements contained in the Magnetic Fusion Energy Engineering Act of 1980 (P.L. 96-385) and to the fusion report of the DOE's Energy Research Advisory Board (ERAB). Many of our members and affiliates also belong to the Atomic Industrial Forum and participated in the formulation of the AIF's study on the "Organization and Management of Fusion Engineering." We support the consensus reached in these reports, namely:

- "The magnetic fusion program can, and should, embark on the next logical phase towards the goal of achieving economic feasibility of magnetic fusion. To this end a broad program of engineering experimentation and analysis should be undertaken under the aegis of a Center for Fusion Engineering (CFE)." (ERAB Report)
- "The DOE should establish a Center for Fusion Engineering operated by a strong, single-line management." (ERAB Report)
- "The concept of the CFE is being proposed . . . with the intent of securing competitive industrial participation." (ERAB Report)
- "Further, it is declared to be the policy of the United States . . . to promote the broad participation of domestic industry in the national magnetic fusion program." (P.L. 96-386)
- "Single line authority for both programmatic and contracting aspects of the engineering effort should be clearly vested in the CFE." (AIF Report)

AND TO IMITATE THE SUN"

"TO TAKE FROM THE SEA

The above reports did not make explicit recommendations on the nature of the organizations which should manage the CFE. The ERAB report, for example, states "This organization could be either an industrial contractor or a national laboratory." The AIF report states that "Priority attention should be directed by government . . . to deciding how the Center should be organized and managed."

To date, the responsibility for the fusion research program has been centered in national laboratories and in universities. An opportunity exists now, as we embark on the "engineering phase" of fusion development, to add a new technical and managerial dimension, a new sense of urgency and purpose, to the fusion program.

The first recommendation which I would make on the establishment of the CFE is that it be industrially managed and that the selection of the industrial contractor be the result of a competitive process.

The industrial sector has a strong interest in active participation in fusion development, including that of prime contractor in selected areas. DOE contracting practices tend to follow historically from those of the Atomic Energy Commission. I would recommend, as better models, the more industry-oriented contracting practices employed by DOD and NASA. There are several successful models which could be followed. One such model is the manner in which the Bettis and Knolls laboratories were established and utilized.

The government must maintain leverage on the industrial contractor, including having the real intent to change contractors periodically if necessary to ensure performance. It is important that the CFE not become another national laboratory. Neither the CFE nor its subcontractors should feel entitled to permanent levels of employment.

The CFE should be allowed to establish industrial procurement and contracting procedures aimed at expediting technical progress, including broad powers to subcontract to other industries and organizations for subsystems development. The CFE should not be subject to the multi-layers of review and approval which currently characterize the contracting practices of DOE field offices, Headquarters and the national laboratories.

The CFE should stimulate the preparation of conceptual designs for power producing experimental fusion reactors based on a variety of concepts and for a variety of applications. Appropriate national laboratories and universities should be integrated with industry into these design efforts.

The CFE manager should report to that official within DOE having responsibility for the overall management of the U.S. magnetic fusion program.

The above recommendations are not presented as exhaustive of the issues. Rather they are an attempt to set forth certain fundamental principles on which to base the establishment of an industrially led fusion engineering development effort.

Strong, knowledgeable and creative national management will be required in DOE to ensure the proper integration of the engineering thrust while continuing to nurture scientific progress in the national laboratories and in universities. This is especially true because scientific progress continues to yield new and improved concepts and because the current engineering designs are not yet obviously attractive as commercial products.



FUSION POWER ASSOCIATES

2 PROFESSIONAL DRIVE, SUITE 248 • GAITHERSBURG, MARYLAND 20780

(301) 258-0545

Members:

Aydin Energy Division (Palo Alto, CA)
BDM Corporation (McLean, VA)
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Burns and Roe, Inc. (Oradell, NJ)
Ebasco Services, (New York, NY)
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Exxon Nuclear Co., Inc. (Bellevue, WA)
General Atomic Company (San Diego, CA)
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Hipotronics (Brewster, NY)
ILC Technology (Sunnyvale, CA)
JAYCOR (Del Mar, CA)
KMS Fusion, Inc. (Ann Arbor, MI)
Mathematical Sciences Northwest (Bellevue, WA)

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Westinghouse Electric Corp. (Pittsburgh, PA)

Affiliates:

Baltimore Gas & Electric (Baltimore, MD)
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Institut de Recherche de l'Hydro Quebec (Quebec, Canada)
Kansas City Power & Light Co. (Kansas City, MO)
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Tri-City Nuclear Industrial Council (Pasco, WA)
University of Illinois (Urbana, IL)

AND TO IMITATE THE SUN"

"TO TAKE FROM THE SEA

Mr. REICHLE. Thank you, Steve. We will probably have questions and comments on your views in a few minutes.

Mr. REICHLE. Our next speaker is Sid Law, director of research for Northeast Utilities, who will present the viewpoint of the Atomic Industrial Forum.

STATEMENT OF SIDNEY LAW

Mr. LAW. Thank you, Len. I am Sidney Law, director of research, Northeast Utilities, and chairman of the Atomic Industrial Forum's Committee on Fusion. It is in my capacity as chairman of the AIF's Committee on Fusion that I am appearing before you today, rather than in my Northeast Utilities capacity.

The Atomic Industrial Forum is an international trade association with over 600 member organizations and is dedicated to the peaceful use of nuclear energy for mankind's needs in energy, medicine, and industrial development. The member organizations of the AIF includes electric utilities, architect engineers, equipment manufacturers, mining and milling companies, labor unions, laboratories, government agencies, financial institutions, and universities. Over 100 of the member organizations are outside the United States.

First, let me thank you for this opportunity to present the AIF Fusion Committee's views on the organization and management of fusion engineering.

In preparation for appearing here today, members of the AIF committee met on June 10 to discuss the issues involved in proceeding with the organization and management of the Center for Fusion Engineering, or CFE, as it is commonly known. I would like to share with you some of the views expressed at that meeting. These are as follows:

First, that the fusion program has credibility and is now at the most cost-efficient point to move forward.

Second, that the Center for Fusion Engineering, or CFE, represents a watershed in fusion programs and is the centerpiece for bringing industrial talents and experience into the program.

Third, that the CFE is necessary to have a meaningful Fusion Engineering Device, or FED, and they should not be separated.

Fourth, that fusion engineering development can be technically justified and moving into this phase is only a question of funding.

Fifth, that if the United States backs away from its fusion program after coming to this point of development, it will have far-reaching consequences and historical significance. It has been reported that the European Community Fusion Review Panel, chaired by Dr. Karl Heinz-Beckurts, will recommend that this generation needs to develop fusion to the point that it can provide an energy potential for the next generation.

These issues are not new and have been discussed at greater length in the AIF committee's report on the organization and management of fusion engineering. Copies of the report are included with my statement.

In appearing before you today, there are three points that the committee members wanted to emphasize:

First, that there is broad support in industry for the fusion program and specifically for proceeding with the CFE/FED to meet the goal of the Magnetic Fusion Energy Engineering Act of 1980. That goal is to have a fusion power facility in operation by the turn of the century which can demonstrate the practical application of fusion energy and serve as a precursor to economically viable powerplants for deployment in the next century.

Second, that now is the time to move into a major engineering program which can build upon the scientific success.

And third, that establishment of the CFE is an essential step toward the commercial development of fusion.

The importance of the CFE to marshal industrial resources cannot be overemphasized. By its very nature, most of the experience in mounting large and complex engineering projects resides within industry. With commercial application not expected until well after the turn of the century, industry's contribution will be primarily through commitment of its resources, experience, and skilled people rather than through substantial monetary outlays.

The AIF committee believes that the characteristics and requirements of the commercial environment for fusion power are markedly different from those which exist in situations where government is the ultimate customer of the product, such as in space or defense.

It is essential, therefore, that those concerned with such marketplace factors as economic, operational, and technical viability be actively involved from the early stages of the development process and that this process be oriented from the beginning toward the goal of commercialization. The CFE is viewed as a critical step in pursuit of this goal.

In closing, let me restate the AIF committee's conclusions on the role of the Center for Fusion Engineering:

First, the objective of the CFE should be the timely development of fusion electric power and other alternatives for energy application. These alternatives include the fusion-fission hybrid which is currently of increasing interest to the utility industry.

Second, successful accomplishment of this objective will require vesting in the CFE single line authority for both programmatic and contracting aspects of the engineering effort.

Third, the role and scope of the CFE should include responsibility and authority for planning and directing fusion engineering development, for establishing an engineering development program on an off-site, and for designing, constructing, and operating the FED. An essential first step is to define clearly the detailed role and scope of CFE activities to serve as a basis for organization and management planning.

Fourth, the Government, in concert with industry, should: Develop criteria for the CFE, including the scope of its activities, its responsibilities, and its authority, and determine the approach to be taken, based on these criteria, for organization of the Center and selection of its management.

Fifth, the fusion engineering device should be located on the CFE site.

Mr. Chairman, the AIF Committee stands ready to assist your Panel in the challenging task you have undertaken. I would be pleased to answer any questions.

[The prepared statement of Sidney Law follows:]

AIF Committee on Fusion
 Testimony by Sidney Law
 Before the Fusion Advisory Committee of the
 Subcommittee on Energy Research and Production
 of the Committee on Science and Technology
 U.S. House of Representatives
 June 29, 1981

Mr. Chairman, I am Sidney Law, Director of Research, Northeast Utilities and Chairman of the Atomic Industrial Forum's Committee on Fusion. It is in my capacity as Chairman of the AIF's Committee on Fusion that I am appearing before you today.

The Atomic Industrial Forum is an international trade association with over 600 member organizations and is dedicated to the peaceful use of nuclear energy for mankind's needs in energy, medicine, and industrial development. The member organizations of the AIF include electric utilities, architect engineers, equipment manufacturers, mining and milling companies, labor unions, laboratories, government agencies, financial institutions, and universities. Over 100 of the member organizations are outside the United States.

First let me thank you for this opportunity to present the AIF Fusion Committee's views on the organization and management of fusion engineering.

In preparation for appearing here today, members of the AIF Committee met on June 10 to discuss the issues involved in proceeding with the organization and management of the Center for Fusion Engineering (CFE).^{*} I would like to share with you some of the views expressed at that meeting. These are:

- o That the fusion program has credibility and is at the most cost efficient point to move forward.
- o That the Center for Fusion Engineering ^{of CFE} represents a watershed in fusion programs and is the centerpiece for bringing industrial talents and experience into the program.
- o That the CFE is necessary to have a meaningful Fusion Engineering Device (FED) and the two should not be separated.
- o That fusion engineering development can be technically justified and moving into this phase is only a question of funding.

- o That if the U.S. backs away from its fusion program after coming to this point of development, it will have far reaching consequences and historical significance. It has been reported that the European Community Fusion Review Panel, chaired by Karl Heinz-Beckurts, will recommend that this generation needs to develop fusion to the point that it can provide an energy potential for the next generation.

These issues are not new and have been discussed at greater length in the AIF Committee's Report on the Organization and Management of Fusion Engineering. Copies of the report are included with my statement.

In appearing before you today there are three points that the Committee members wanted me to emphasize:

First, that there is broad support in industry for the fusion program and specifically for proceeding with the CFE/FED to meet the goal of "The Magnetic Fusion Engineering Act of 1980." That goal is to have a fusion power facility in operation by the turn of the century which can demonstrate the practical application of fusion energy and serve as a precursor to economically viable power plants for deployment in the next century.

Second, that now is the time to move into a major engineering program which can build upon the scientific success.

And third, that establishment of the CFE is an essential step toward the commercial development of fusion.

The importance of the CFE to marshal industrial resources cannot be overemphasized. By its very nature, most of the experience in mounting large and complex engineering projects resides within industry. With commercial application not expected until well after the turn of the century, industry's contribution will be primarily through commitment of its resources, experience, and skilled people rather than through substantial monetary outlays.

The AIF Committee believes that the characteristics and requirements of the commercial environment for fusion power are markedly different from those which exist in situations where government is the ultimate customer of the product, such as in space or defense.

It is essential, therefore, that those concerned with such marketplace factors as economic, operational and technical viability be actively involved from the early stages of the development process and that this process be oriented from the beginning toward the goal of commercialization. The CFE is viewed as a critical step in pursuit of this goal.

In closing, let me restate the AIF Committee's conclusions on the role of the Center for Fusion Engineering:

- o The objective of the CFE should be the timely development of fusion electric power and other alternatives for energy application. ✓
- o Successful accomplishment of this objective will require vesting in the CFE single line authority for both programmatic and contracting aspects of the engineering effort.
- o The role and scope of the CFE should include responsibility and authority for planning and directing fusion engineering development, for establishing an engineering development program on and off-site, and for designing, constructing, and operating the FED. An essential first step is to define clearly the detailed role and scope of CFE activities to serve as a basis for organization and management planning.
- o The government, in concert with industry, should:
 - Develop criteria for the CFE, including the scope of its activities, its responsibilities, and its authority.
 - Determine the approach to be taken, based on these criteria, for organization of the Center and selection of its management.
- o The fusion engineering device should be located on the CFE site.

Mr. Chairman, the AIF Committee stands ready to assist your panel in the challenging task you have undertaken. I would be pleased to answer any questions you or members of the panel may have.



**A Report on the
Organization and Management
of Fusion Engineering**

Prepared by
The Atomic Industrial Forum
Committee on Fusion

January 20, 1981

Atomic Industrial Forum, Inc.
7101 Wisconsin Avenue
Washington, D.C. 20014

Introduction

Congress recently enacted legislation, "The Magnetic Fusion Engineering Act of 1980," calling for initiation of a major engineering effort in the magnetic fusion program. The goal of the legislation is to have a demonstration fusion power plant in operation by the turn of the century. Such an effort, estimated to cost \$20 billion, will require a national commitment. Achieving that goal will provide the nation and the world with an inexhaustible energy source for commercial deployment in the 21st century.

As a first step in this major engineering effort, the legislation calls for the establishment of a Center for Fusion Engineering (CFE) to serve as the focal point for engineering development. Centerpiece of the facility and initial focus of its activities will be a Fusion Engineering Device (FED). The design and construction of the FED will serve to demonstrate the engineering feasibility of magnetic fusion and, combined with the results of its operation, help define the course toward the national goal of operating a demonstration plant by the end of the century.

The legislation does not specify how such an effort can best be organized and managed but directs the Department of Energy (DOE) to submit a report to Congress by July 1, 1981 on establishment of the engineering center and associated program management. It is the purpose of this AIF Committee on Fusion* report to examine some of the issues raised and to suggest an approach for coming to grips with this complex and challenging question.

Findings

In weighing various alternatives, the Committee found that:

- Establishment of a center for fusion engineering is an essential step toward the commercial development of fusion energy.
- The primary objective of the CFE should be the achievement of safe, reliable, environmentally compatible, and economically competitive fusion electric power and other fusion alternatives for energy application.
- Priority attention should be directed by government toward defining the scope, authority and responsibilities of the projected Center as an essential prerequisite to deciding how the Center should be organized and managed.
- To this end, the government, in concert with industry, should:
 - develop criteria for the CFE, including the scope of its activities, its responsibilities, and its authority
 - determine the approach to be taken, based on these criteria, for organization of the Center and selection of its management.
- Criteria for the CFE might appropriately include:
 - Planning and directing a staged development program that will demonstrate sound engineering features for a commercial power reactor system. This development program should not be limited to the Tokamak concept and should include other feasible approaches.

- Undertaking as an initial step and focal point in this process, the design, construction and operation of a fusion engineering device to demonstrate engineering feasibility and test components suitable for integration in successive systems leading to a demonstration plant by the year 2000.

- Establishing an engineering development program, on and off the CFE site, to assure proper program balance for commercial development.

- Pacing the program to minimize the total cost of development.

- Single line authority for both programmatic and contracting aspects of the engineering effort should be clearly vested in the CFE.
- This authority should be vested and exercised at a government level commensurate with the scale and importance of a national undertaking involving the commitment of \$20 billion over a 20-year period.
- Siting of the CFE should be given priority so as to establish a firm basis for planning in those organizations from which the key individuals necessary to staff the center and carry out its mission will be drawn.
- CFE management, in turn, should have responsibility for developing the requirements for the projected FED and for selecting, on a competitive bid basis, a prime industrial contractor for the design, construction, and installation of the device at the Center. CFE management should be the final arbiter on the FED conceptual design.
- The FED should be located at the CFE site to facilitate effective management.
- Mechanisms need to be provided for active input to the CFE from the utilities as ultimate users of the technology and from the national laboratories where much of the experience in the physics aspects resides.

Discussion

A primary motivation for enactment of the legislation is the consensus within the fusion community that the demonstration of fusion's scientific feasibility is virtually at hand, as evidenced by recent successes in the research program. It is now time to move into a major engineering program which can build upon this scientific success. This effort should be directed toward building and operating a plant by the end of this century that can demonstrate the practical application of fusion energy and serve as a precursor to economically viable powerplants for deployment in the next century.

This challenging task will require a commitment to marshal the necessary resources from all sectors, especially industry, and the national laboratories and universities. This will mean finding committed organizations and key people with the required talents and experience, wherever they may be, and vesting in them the authority, responsibility, and resources needed to carry out the task successfully.

By its very nature, most of the experience in mounting and managing large and complex engineering projects resides within industry. With commercial application not expected until

*The members of the Committee on Fusion are listed in Appendix I of this report.

well after the turn of the century, industry's contribution will be primarily through commitment of its resources, experience, and skilled people rather than through substantial monetary outlays. The top management of industrial companies must carefully weigh the commitment of these resources against competing demands in other areas, many of which may offer earlier return on investment. Critical to such commitment on the part of industrial management is confidence that the effort taken in mounting the fusion engineering program will continue to receive the support and resources from government to see the program through to a successful conclusion.

Transition to Engineering

As noted in this Committee's earlier report, the launching of a major engineering effort requires a successful transition from primary emphasis on physics, which has characterized the fusion program to date, to emphasis on engineering development, supported by a strong and continuing physics program. This transition will be a difficult one and will mandate a series of conscious policy changes to be carried out effectively. Moreover, as directed in the legislation, it will require a programmatic shift and change in location of the ongoing engineering effort into a separate activity.

It is important that the scope and role of the separate activity, which is identified as the Center for Fusion Engineering, be spelled out carefully before final judgments are made on arrangements for organization and management of the engineering program.

The Evolution of the Center for Fusion Engineering and the Fusion Engineering Device

In its initial phases, the discussion within government on mounting a major engineering effort for magnetic fusion centered on what was termed an engineering test facility (ETF). As originally visualized, the device in that facility represented substantial extrapolations of the physics and engineering parameters in existing devices. The Fusion Review Panel chaired by S. J. Buchsbaum of DOE's Energy Research Advisory Board concluded* that the risks associated with incorporating such extrapolations into one device were unacceptably high and recommended the construction of a less ambitious device which would be more likely to meet its technological and cost objectives.

Further, the panel thought that the concept of an engineering test device by itself was too narrow an approach to the broader problems associated with mounting a successful engineering development program for fusion. It recommended that a center for fusion engineering (CFE) be set up to undertake this broader task and that the more modest device it had recommended, the Fusion Engineering Device (FED) be constructed at the center as the focal point for its initial activities. This approach was incorporated in the legislation and has been adopted as official policy by DOE.

It is important to recognize that in the evolution of policy between the original ETF concept and the CFE/FED approach recommended by the Buchsbaum panel, commercial

fusion power was removed as a primary goal of the engineering program. The more limited capability of the FED as compared with the ETF will result in the need for increased emphasis on the successive steps beyond the FED which would be necessary to achieve the demo objective. These program elements should be addressed promptly, together with their estimated costs and time scales.

Considerations in Weighing Organization and Management Alternatives

In weighing alternative approaches to the organization and management of the projected engineering center, the Committee believes it important to recognize that the characteristics and requirements of the commercial environment for fusion power are markedly different from those which exist in situations where government is the ultimate customer of the product, such as in space or defense. It is essential, therefore, that those concerned with the economic as well as technical viability in the marketplace be actively involved from the early stages of the development process and that this process be oriented from the beginning toward the goal of commercialization.

Pursuit of this goal requires that the organization and management of a complex undertaking such as the engineering development of fusion power be mounted in a way which will permit the achievement of this objective in an orderly and cost effective manner. Equally important is establishment from the beginning of appropriate relationships among those who will be charged with carrying out this task and those who will be responsible for distributing the ultimate product to the American consumer.

It is recognized that the development of fusion energy for ultimate commercial application is still at an early stage. Physics problems remain to be solved, the technology is still being developed, and the precise characteristics of the device to be incorporated in an operating fusion powerplant are as yet unknown. Nor is there any certainty that the next major step — development of an engineering testbed to demonstrate engineering feasibility and test components — will lead directly to the design of a commercially viable powerplant.

Nevertheless, despite these uncertainties, the success of the major engineering effort about to be mounted will depend in considerable measure on how well the program is oriented toward the goal of ultimate commercialization and its inherent requirements. The approach and structure of the program, including a workable relationship among the major participants, must be tailored accordingly. Conversely, if program orientation and structure are developed in an environment where the government comes to be viewed as the customer of the product and program objectives are formulated on a roll-forward basis as the program progresses, then certain consequences necessarily follow.

These include a tendency for the government, particularly where it is providing the lion's share of the funding, to assume technical direction of the effort and for the goals of that effort to be diffused toward developing information

*Report on the Department of Energy Magnetic Fusion Program prepared by the Fusion Review Panel of the Energy Research Advisory Board, August 1980.

as an end in itself, rather than tied to commercialization objectives. Without the disciplines inherent in the latter, there is high risk that commercialization goals will never be achieved and that costs will escalate beyond politically acceptable levels. There is ample evidence for this contention in a study performed several years ago by the Rand Corporation* on cooperative projects undertaken in the past by industry and government.

Another difficulty in building a healthy industrial base is the perceived reluctance on the part of DOE to award follow-on business to firms that participated in prior concept definition studies. This reluctance appears to stem from policies and procedures in the DOE procurement process which tend to exclude those firms with prior involvement. This situation could be remedied in large measure if, in its procurement practices, DOE were to follow the provisions of OMB Circular A-109, "Major Systems Acquisition," which establishes policies to be adopted by Executive Branch agencies in the acquisition of major systems. Steps to implement this policy should be taken now.

Organization and Management Approaches

In reaching its findings and conclusions, the Committee evaluated the following organization and management approaches for the CFE:

• Solicitation of Competitive Proposals

In this approach, management of the Center for Fusion Engineering would be selected by solicitation of competitive proposals from the major sectors of private industry. The winner of this competition could be a single entity i.e., a manufacturing company, architect-engineer-constructor, etc., or some combination of these organizations. The CFE management would have responsibility for construction and operation of the FEL, for other engineering test facilities, and for coordinating all engineering activities in the magnetic fusion program. It would inherit all of the precognitive design work on an engineering device performed by the present design center at Oak Ridge and would have responsibility for developing an RFP to industry for conceptual design of the device. The arrangement for transfer of the design work already accomplished would not limit the flexibility of the CFE management in developing a final design. After evaluating the responses, the CFE management would make its selection in concert with its governing organization, and successive design and construction activity would then proceed through industrial contracts with the engineering center. Whoever is selected to manage the CFE would presumably be precluded from bidding on the prime contract for design and construction of the FED because of conflict of interest, but would be permitted to bid on subcontracts involving the manufacture of system components. Some parallels to this approach are found in the

procedures used in selecting the organization to build and operate the Elmo Bumpy Torus Proof of Principle EBT(P) device.

• Special Project Office

A variation of this approach would call for establishment of CFE management by competitive bid and then setting up a separate parallel special project office, either in Washington or in the field, to oversee the design and construction of the FED. The CFE would retain responsibility for coordinating the overall fusion engineering program and would lend support to the special project office in the R&D associated with design and construction of the device. The special project office, as in defense and space programs, would be abolished once construction and check-out were completed and the CFE assumed responsibility for operation of the device. This concept is comparable to those Special Project offices established in the Apollo program.

• Corporate Entity Concept

This approach would establish the CFE as a separate corporate entity, possibly under Congressional charter, and charge it with carrying on the fusion engineering program through the demonstration phase. This would include responsibility for design and construction of the FED, contracted out to the private sector on a competitive basis; for the supporting R&D program on and off-site; and for guiding the program through the successive steps necessary to reach the demonstration plant stage by the turn of the century.

A board of directors, appointed by the President, would be responsible for the operation of the CFE. The board would be comprised of senior level individuals experienced in the management of large engineering projects and drawn from the major institutions involved, including the utilities, architect-engineers, industrial firms, the universities, and the national laboratories. A line management organization headed by an executive director vested with appropriate authority and responsibility to carry out the center's mission, would be established under the direction of the board. Models of this concept which suggest possible avenues for further consideration are Comsat and the recently established Synfuels Corporation.

• Partnership Arrangements

Distinguished from the above corporate concept are several examples from the past where corporate bodies, in the form of industry-sponsored organizations, entered into partnership arrangements with the government to advance fission energy for power production:

- In the Shippingport model, technology developed for submarine reactors was applied to commercial usage through industrial contractors under the technical direction of the government.

*Analysis of Federally Funded Demonstration Projects: Final Report (The Rand Corporation, R-1926, Doc. Santa Monica, California, 1976)

- In the Yankee-Rowe demonstration plant regional electric utilities provided the technical direction and contracted the work to industrial architect-engineer and equipment supplier firms through normal commercial channels.
- In the liquid metal fast breeder program, the electric utilities established the Breeder Reactor Corporation to serve as a vehicle for financial contributions to the program and a Project Management Corporation for carrying out the Clinch River breeder project, in concert with the government.
- In the helium fast breeder reactor, a utility-sponsored body, Helium Breeder Associates was organized to act as the developer and "surrogate owner" of a helium fast breeder. Under this concept the utilities, as ultimate users of the technology, assumed technical direction and management of the program, provided guidance on development work to be contracted out to the private sector, and in concert with government, arranged for active participation of the national laboratories. Removal of government support in the past year has placed a hold on the program.
- In a similar joint effort an electric utility sponsored group, Gas Cooled Reactor Associates, is proceeding in its program designed to advance technology for the high temperature gas-cooled reactor.

Conclusion

Effective organization and management of the major engineering effort on which the magnetic fusion program is about to embark are critical to solving the complex prob-

lems inherent in taking a technology which is just now emerging from the laboratory and advancing it to engineering practice. To accomplish this, the Committee concludes, based on its findings and the considerations weighed in this report, that:

- The objective of the CFE should be the timely development of fusion electric power and other alternatives for energy application.
- Successful accomplishment of this objective will require vesting in the CFE single line authority for both programmatic and contracting aspects of the engineering effort.
- The role and scope of the CFE should include responsibility and authority for planning and directing fusion engineering development, for establishing an engineering development program on and off-site, and for designing, constructing, and operating the FED. An essential first step is to define clearly the detailed role and scope of CFE activities to serve as a basis for organization and management planning.
- The government, in concert with industry, should:
 - Develop criteria for the CFE, including the scope of its activities, its responsibilities, and its authority.
 - Determine the approach to be taken, based on these criteria, for organization of the Center and selection of its management.
- The fusion engineering device should be located on the CFE site.

The Committee stands ready to assist in the challenging task of developing criteria, defining the role of the CFE, and establishing an organizational and management framework which can bring into being a demonstration fusion power plant by the turn of the century.

APPENDIX I

FUSION COMMITTEE MEMBERS

Chairman: Sidney Law Director of Research Northeast Utilities	William A. Frederick Manager — Advanced Projects Pennsylvania Power & Light Co.
Secretary: Frank W. Graham Special Studies Manager Atomic Industrial Forum, Inc.	*Harold K. Forsen President Jersey Nuclear-Avco Isotopes, Inc.
**William O. Allen Advanced Physical Processes Development Manager Bechtel National, Inc.	Robert W. Goodrich Senior Scientist Northeast Utilities
W. B. Allred Consulting Engineer Stone & Webster Engineering Corporation	E. R. Hottenstein Manager, Advanced Technology Gilbert Associates
Clinton P. Ashworth Supervising Mechanical Engineer Pacific Gas & Electric Company	Henry Hurwitz Physicist General Electric Research and Development Center
**G. Edwin Brown, Jr. Management Consultant	**Thomas S. Latham Chief, Fusion Engineering and Technology United Technologies Research Center
Sibley C. Burnett Manager, Fusion Program Development Department General Atomic Company	James A. Maniscalco Manager — Fusion Energy Systems Advanced Technology Laboratory TRW, Inc.
R. Bryan Cairns Advanced Technology Manager Boeing Engineering and Construction Company	Albert B. Martin Program Manager Fusion Programs, Energy Systems Group Rockwell International
Colin S. Caldwell Scientist of Material Technology Laboratory Lynchburg Research Center The Babcock & Wilcox Company	Kenneth L. Matson Vice President PSE&G Research Corporation
Ralph S. Cooper Deputy Director Radiation Physics Division Physics International Company	Frederick J. Milford Associate Director for Research Battelle Columbus Laboratories
Howard R. Drew Executive Vice President Texas Atomic Energy Research Foundation and Texas Utilities Services, Inc.	**Alfred E. Munier Director of Advanced Energy Systems Grumman Aerospace Corporation
**Edward C. Fiss Senior Staff Consultant Advanced Generation Concepts Duke Power Company	N. Thomas Olson Senior Staff Scientist Maxwell Laboratories
	**Leonard F. C. Reichle Executive Vice President Ebasco Services, Inc.

*Chairman, Subcommittee on Organization and Management of Fusion Engineering

**Member, Subcommittee on Organization and Management of Fusion Engineering

Peter Rose
President
Mathematical Sciences
Northwest, Inc.

Carl H. Rosner
Chairman and Chief Executive
Intermagnetics General Corporation

Gunnar E. Sarsten
Vice President — Power Division
United Engineers and Constructors, Inc.

**Zalman M. Shapiro
Manager
Westinghouse Fusion Power Systems

Charles L. Storrs
Director, Advanced Development
C-E Power Systems
Combustion Engineering, Inc.

Alvin W. Trivelpiece
Corporate Vice President
Science Applications, Inc.

Mr. REICHLE. Thank you, Sid.

I would like to start questions on the first panel by asking Steve Dean what problems, if any, do you think the DOE might have in the establishment of an industry-run CFE? You have been inside the DOE. You know the DOE.

Dr. DEAN. Probably one should ask the DOE that question.

I think there are two problems, personally, that will come up. One is a contracting procurement problem. It has to do simply with the redtape they foresee of having to go through with processes that they have set up for themselves in making such a selection. They will see it as a long, drawn out, complicated process that they would just be resistant to taking the time and making the effort to go through. That is going to be one problem of getting the thing going within the DOE.

The other is a more philosophical problem; that is, that I think historically the DOE, at least in the fusion program, has done business without going through a competitive process that one necessarily has to go through in dealing with industry. They have dealt mostly with the national laboratories under financial plans, so whatever they wanted to do they could just write a memorandum and send them the money. They have dealt mostly on the basis of unsolicited proposals from universities and laboratories.

I think in working to establish a CFE, there will have to be what I call a radical change in their management procedures, programatically, of dealing with industries on an RFP and competitive selection process. I think they are not yet psychologically prepared to do that.

Mr. REICHLE. You think the contracting procedure necessarily has to be long and complicated?

Dr. DEAN. No. I think the top layers of management have laid these procedures on themselves. I see no reason why they should not get rid of them; but they do not seem to be able to do it.

I think the contracting and procurement tail wags the programmatic dog in the DOE.

Mr. REICHLE. Do other panel members have questions and comments?

Dr. FURTH. Well, I would like to ask one question. I notice in Mrs. Bouquard's charge to this panel only half the questions deal with the characteristics of the CFE. The other half has to do with the question, do we want a CFE?

For instance, the first question is whether the CFE is, in fact, needed to bring about real industrial involvement or is it only one of many possible avenues.

Now, neither of the speakers addressed that. Would you care to comment, either one?

Mr. LAW. Well, I will take a crack first.

It is the strong position of the AIF that the CFE or something very similar is necessary to provide some sort of continuity to a long-range program such as the fusion program.

Government bodies have a tendency to change over a period of time and we really need that continuity if fusion is going to be a success.

Dr. FURTH. So your answer would be that the CFE is only one of many possible avenues you would see for involving industry?

Mr. LAW. I am not saying there are not other ways of involving industry; but whatever it is, it should be set up to provide the continuity that is necessary to reach the goal.

Dr. FURTH. How else would you involve it?

Mr. LAW. We have not given too much thought to anything else, since the bill that Mike McCormack put through identified specifically a CFE.

Dr. DEAN. I would like to add that it was the strong recommendation of the ERAB Panel that created the concept of the CFE. I think that that recommendation was soundly based. It seems to be generally agreed that the program needs to move into engineering development, which is a new element in the program by and large, aimed at developing a commercial product.

My view would be that that part of the program that is trying to solve those problems and develop that product should be industrially led and managed.

Now exactly how that is done and whether or not you call it a CFE I would be willing to have a discussion on, but it seems to me that the concept of an industrially led engineering phase of fusion with an organization that can then subcontract out for appropriate work to other industries is the right concept for engineering development of fusion in the eighties as a complementary part to the research program based in the laboratories and universities.

Mr. McCORMACK. I would like to pursue this point further.

I think it was the Buchsbaum Panel that came up with the concept of the CFE. It was their recommendation that came actually between the version that passed the House and the version that passed the Senate. We readily accepted that because we thought it was a very constructive approach.

Steve, you and Mr. Law both are expressing the need for having industrial leadership and participation and competition and so on in the management of the CFE; but we still have sort of a vacuum between what we can easily see as the CFE functions and specifically how we bring the formation of such a Center about.

What sort of an entity do you conceive of existing here? What is it if we pick it out of, as you say, the multilayers of review and approval, and I presume take it out of the vagaries of annual congressional budgeting for its existence? How would you stabilize it? What kind of an entity would you create or do you conceive of one that would do this?

Dr. DEAN. Well, I do not think you can take it out of the annual appropriation process.

Mr. McCORMACK. I mean its existence; obviously, the budget level is going to be controlled by Congress.

Dr. DEAN. Yes.

Mr. McCORMACK. I am talking about its existence.

Dr. DEAN. I think its existence—it should become a part of the national fusion program. As I mentioned, its manager, I think, should report to that official within DOE who has overall responsibility for the fusion program so that it becomes a part of the national fusion program in an integrated way and that that contrac-

tor has primary responsibility for laying out and managing the engineering phase of fusion. That includes planning the program, finding out what the engineering problems are, setting up the priorities and contracting out for the work.

Now, that does not mean that they operate independently of that individual in DOE who sets the priorities for the overall program; but it does mean that that organization has a responsibility. It is in some sense in the same way that Livermore has lead laboratory responsibility for magnetic mirror research.

This entity, I think, would have essentially the responsibility to plan out and implement with approvals the engineering development tasks required.

Mr. LAW. We certainly agree with Steve. It should report very definitely somebody within the DOE; but we feel that the level that it should report within DOE should be consistent with a \$20 billion program, and perhaps the present level is not consistent with that.

Mr. REICHLE. Would either of you object if it were not included in DOE, but rather made an independent entity of some kind?

Mr. LAW. We certainly would not object.

Dr. DEAN. I would not object unless that meant that it were then separated from the research program. If you left the research program in the DOE and established a separate entity for the engineering, I think that would be a disaster.

Mr. McCORMACK. Well, let us imagine a NASA. Let us imagine for a moment creating a NASA for fusion, shall we say, a national fusion administration and put the research program under it along with the entire engineering development program. How does that strike you?

Mr. LAW. I think that is fine.

Dr. DEAN. Yes.

Mr. McCORMACK. Then you would have continuity.

Mr. LAW. Absolutely.

Dr. DEAN. I think the key in all our comments has been that it should have a single line management. I think not only should the engineering in the CFE have a single line management, but the program as a whole has got to have a clearly defined chain of command in its management structure.

Mr. LAW. We agree.

Mr. BLATTNER. You set NASA as an example. Do you mean by that that it would be a Government agency per se, or do you mean to include other nonprofits in that statement?

Dr. DEAN. I interpreted what Mike was saying by "a NASA for fusion" to mean that they would put in an industrial manager for the Center for Fusion Engineering as contractor to this "new NASA." I didn't take what he said to mean that this "NASA organization" of Government employees would in fact do the engineering. Maybe I misunderstood.

Mr. McCORMACK. I don't have a preceived notion. I was just fishing around for ideas.

Dr. DEAN. Regardless, you suggested a new agency to replace the DOE responsibilities, and that's fine. I don't think that removes the need for an industrially managed Center for Fusion Engineering

and the need to have that new agency contract out to private industry for this job.

Mr. REICHLE. Do you visualize the "fusion NASA" simply as a Government organization in which to pool the fusion work now performed under the DOE, together with an industrially managed and technically directed Center for Fusion Engineering; is that it?

Mr. LAW. Yes.

Mr. REICHLE. I have a question for Sid Law.

As a utility man, how do you feel we could best get the input of the electric utility industry into a CFE?

Mr. LAW. Well, the utility industry very definitely wants to be part of the advisory function that would be working with the CFE, and we have several methods for doing that. Through EPRI is certainly one. We are also a strong part of the AIF, and this would be a second way of doing it.

It is conceivable that there could be a separate group of individual utilities that might work on specific problems with the CFE.

Mr. REICHLE. Are there other questions or comments from members of the panel?

Mr. CAIRNS. Sid, how broad a responsibility would you say the CFE would have? For example, what would be its role vis-a-vis the fusion-fission hybrid?

Mr. LAW. It very definitely should have something to say as far as the hybrid is concerned. If the hybrid looks feasible—and the studies are going on right now to look into that—it should be part of the FED. There should be a way of working the hybrid into the engineering device.

Dr. LANDIS. Steve, just how broad is the support for fusion among various facets of industry? I know about the membership of your organization, but I see great holes in the membership, in that some industries are not represented at all that are energy intensive.

Dr. DEAN. You have to realize that Fusion Power Associates only began 18 months ago and industries are still gradually becoming aware of our existence and joining. I know that our membership is not indicative at this point of the total interest there is out there.

I think another way to look at this problem is that one of the reasons you don't have more industries showing the flag and showing their interest in fusion is the fact that there have been few opportunities for them to participate. They have by and large felt, I think, that they have not really been wanted except in specific cases in subsidiary roles to supply bits and pieces of studies and contracts to national laboratories.

I think if we create a different atmosphere and indicate—the way NASA did when they started the space program—that it is our intent to do this job with industry and with participation, and that there will be opportunities for industrial participation, I think you will find then very quickly that there is in fact a very large interest out there by all the high technology companies in this country, and that they will want to participate.

Dr. LANDIS. Have you or the forum, Sid, ever taken a poll as to industrial interest?

Mr. LAW. We have not taken a poll as such but in 1979 members of the AIF committee visited many members of industry, utilities and industrial organizations, and the result was our report on

industry's role in fusion development which came out a little over a year ago. Have you seen that, John?

Dr. LANDIS. I don't know whether I have or not.

Mr. LAW. We have a copy of it for you, if you would like. We have identified a great deal of interest, and in recent days the interest has certainly been growing.

Dr. LANDIS. So you would say there is broad interest; right?

Mr. LAW. Oh, yes.

Dr. DAVIDSON. Steve, in your opinion how broad would the CFE responsibility be for fusion technology development beyond the fusion engineering device per se?

Dr. DEAN. Well, I have had different views on this over the past several months. As you know, this is an evolving situation. I am sort of coming around to the view that it needs to be very broad, the reason being that this is a whole new area and it is very complex and it needs to be very systematically addressed before we embark on it because it is so expensive.

And another thing, it is not clear to me when the FED will really get funded. It is a desirable thing, but it is an expensive item, and I don't think we want the whole engineering effort to stand or fall on whether or not this particular machine can get in the budget in a particular year. So I think we need to get this whole concept of an industrially planned and managed engineering program moving, independent of the FED, and in that case it seems to me the organization will have to have broad responsibilities.

Dr. DAVIDSON. Does the Atomic Industrial Forum have a similar view?

Mr. LAW. Yes.

Dr. DAVIDSON. Sid, you mentioned that it was the opinion of the Atomic Industrial Forum that the Fusion Engineering Device should be sited at the CFE site, if I recall you correctly.

Does that mean that you envision a single prime contractor for both the CFE and the FED? Are they to be the same contractor?

Mr. LAW. On the contrary, we would expect that the CFE would advertise for bids, perhaps for a contractor specifically for the FED.

Dr. DEAN. I think it is very important that the CFE charter and its management realize that its job is not to take over the fusion engineering development for its own corporate benefit but to involve others on a competitive basis and to be committed to selecting and bringing in on a competitive participatory basis a broad cross section of the U.S. industry into this effort.

Dr. ROSENTHAL. Steve, the views on the CFE sometimes range from being a management organization to being a laboratory. Would you state where you view the organization coming down, at one of those extremes or in between?

Dr. DEAN. Well, I think the primary function of the CFE contractor is to be a manager of the engineering effort, and as I mentioned, it should bring in a lot of subcontractors and other prime contractors for major jobs like FED to perform its functions. So its major skill, it seems to me, should be as a manager, and exactly when it takes over a site, and so on, I think, will be determined as things evolve. But I think its major skill and role in the program is to manage the engineering development phase of fusion, and if it

does not do a good job, as I mentioned, I think that we should not feel that we should stick with that particular contractor for 15 years. If it isn't doing our job, we should feel that we have the intent to change contractors if in fact it is not managing the program properly.

Dr. ROSENTHAL. Mr. Law. Do you have the same view?

Mr. LAW. Yes.

Mr. REICHLE. By "manage" I assume you mean not just budget but technical planning and technical cognizance, also, as part of the concept of management?

Mr. LAW. Absolutely.

Mr. MCCORMACK. I would like to explore that. You raise an interesting question.

Let's imagine that a CFE has a headquarters, no laboratory at all; it is a headquarters for management, and you recommend that it fit the same size group with the FED. Now, we have the CFE, which has a building presumably with a minimum of offices, and then you have a FED, which is a multihundred megawatt thermal device. The purpose, of course, is engineering development and materials testing. A lot of that would logically be done onsite or very nearby, materials testing as a classic example. You are going to have a lot of hot materials and a lot of hot lab work, for instance.

Obviously, the make-sense situation, it seems to me, is to have them all behind or inside one fence. This means a participating series of contracts.

It seems to me that what you do as soon as you do that, as soon as you accept that concept, is assume what you are really developing is a laboratory onsite along with the FED, as supporting the FED and perhaps supporting them ultimately for the projects beyond that FED.

Is that inconsistent with your thinking?

Dr. DEAN. I would not necessarily agree with the position expressed by Sid. I think, if I understood it properly, that his position was that the FED must be at the CFE site. I think that the CFE contractor has to manage the national engineering program, and it is going to have development going on, components and facilities that it is managing at several sites. One of its projects will be at the site of the Fusion Engineering Device, but, in fact, it may have delegated this out under a prime contract to some other contractor to actually operate that FED site or some parts of that site.

Also it seems to me quite possible there could be several industrial contractors doing various things at that particular site and still have the CFE organization managing it. That does not mean that FED is the only site or even the headquarters site of the CFE contractor itself.

I don't really know exactly how this is all going to evolve, but I do believe the CFE should be a management contractor, and it has to be strong enough and involved enough that it is not overwhelmed by the FED job or by the FED prime contractor.

I don't know if that quite answers your question. The CFE has to be the "top dog," it seems to me. It doesn't mean he cannot prime out the FED job to another contractor.

Mr. REICHLE. How large a staff do you visualize the CFE might have within 2 years?

Dr. DEAN. I really don't know. It seems to me that within a few years he can't get by with less than 100 or 200. I don't imagine the CFE should ever have on his payroll 5,000 people. If he does, then he has become a national laboratory and he is then not doing his job of bringing in other industries to work in this program.

Dr. LANDIS. Steve, is there any institutional framework in the United States or anywhere else in the world that is similar to what you are espousing here?

Dr. DEAN. There are probably others who could answer that better than I, but it seems to me there are probably a number of different examples around in the Defense Department where they have had systems management contractors who in fact have managed the procurement and the assembly and the production and eventual implementation of major weapons systems. That is one.

And it seems to me that, as I mentioned, in the case of the Bettis and Knolls Laboratories that is a possible model for stimulating the development of a total system such as the naval reactor system.

Dr. LANDIS. My question was broader than that. You mentioned earlier that this is somewhat different than a situation where the Government is the main procurer and the main ultimate customer, and I am trying to think where in the world there is something similar to what you are proposing.

Dr. DEAN. Well, I think a purpose of the CFE is also not to become the supplier of commercial reactors but to give birth to a commercial vendor reactor industry. So you don't want a CFE, it seems to me, to set itself up or to think in terms that you must set up a process whereby the CFE is eventually going to sell reactors to utilities.

So what we are talking about here is getting the engineering phase going by an industrially managed organization. And exactly when that might be superceded by some industries that stand on their own feet and compete commercially on their own independent of the CFE, at that point it seems to me it would be the greatest thing going if General Atomic or General Electric decided to move this whole thing independent of the CFE.

Mr. SPENCER. If I could pursue John's question a little further—I thought it was an excellent one—I, too, am very concerned about what the institutional framework is that really represents industry in the context of the engineering device capability, the utility utilization capability, and the manufacturing capability, and I think trying to find an institutional framework that represents all those interests is a very difficult undertaking.

So I would like to just ask you one more question, if I might. Do you envision perhaps a private nonprofit organizational entity being established that would be essentially sponsored by this broad range of industry as a mechanism for providing such direction?

Dr. DEAN. I think you could imagine it, but I think it would be a lousy idea, frankly, even though I represent a nonprofit organization. I believe you would be much better off and would get a much better job if you competitively select an organization that in fact knows what it is doing from the start and already has a reputation in its management structure. When you put together these ad hoc organizations, you are really not sure what you are going to get.

Mr. SPENCER. My concern with that is this: If you give it to just GE or just Westinghouse, you would have a very difficult time competing by having everyone's interests being served.

Mr. LAW. I don't think we at AIF feel there has been the model established for this as yet. This is part of the problem, and part of the study that is necessary is just what the CFE should be and what it should do and how it should be organized.

Mr. REICHLE. If there is no objection by other members of the panel, I think, in order to get the views of our next panel, the top level industry men, we might move on.

Do you have something special, or should we move on?

Dr. OHKAWA. I have one question.

Both of you emphasized the competitive process for selecting CFE. The chairman's letter states, FED's title I no later than 1984. This means FED's approximate design and cost must be known within a year for budgetary purposes. The competitive process may delay this date. Which would you put a priority on, the competitive process or the 1984 date?

Dr. DEAN. I think it is important to do the job right rather than meet some artificial date.

Mr. REICHLE. Thank you very much, Steve and Sid.

Now, may we have the next panel? The next panel will be comprised of Dr. Harold Agnew, Mr. Frederick Maxwell, Mr. Bob Sherman, and Mr. Larry Mead.

Our first speaker will be Dr. Harold Agnew, president of the General Atomic Co.

STATEMENTS OF DR. HAROLD M. AGNEW, PRESIDENT, GENERAL ATOMIC CO.; FREDERICK MAXWELL, PRESIDENT, BOEING ENGINEERING & CONSTRUCTION CO.; ROGER J. SHERMAN, CHAIRMAN OF THE BOARD, EBASCO SERVICES, INC.; AND LAWRENCE M. MEAD, JR., SENIOR VICE PRESIDENT, ENGINEERING, GRUMMAN AEROSPACE CORP.

STATEMENT OF DR. HAROLD M. AGNEW

Dr. AGNEW. Mr. Chairman, I am Harold Agnew, president of the General Atomic Co.

As you know, General Atomic is a private company which has been involved in fusion power research and development for over 20 years. Beginning in the early sixties, we engaged in a privately funded fusion program for the Texas Atomic Engineering Research Foundation. That program led to many others, sponsored by our company, by the utility industry, and for the past 15 years by the U.S. Government. Since 1979 we have also enjoyed the joint sponsorship of the Government of Japan in a cooperative program of fusion research on our Doublet III device. General Atomic has thus built the largest fusion research program based in an industrial company in the United States and perhaps—depending on how you define "private"—in the world.

For me it is from an interesting perspective that I come to testify before you today. Several years ago I retired from the directorship of the Los Alamos Scientific Laboratory. It is an interesting bit of history that in 1950 I was serving in the Director's Office when a person came in by the name of Jim Tuck. Jim Tuck had a wild

idea. At that time you remember we in the weapons field were worrying about a thing called Super, which had to do with the burning of deuterium. Tuck convinced us that he had a way of helping to better understand this primary fusion process, and he had a way of doing it in a box, and for those of us who were under great pressure at the time, trying to understand the fusion mechanism, we thought this was a program that could indeed help the weapons program, so we urged the Director that we go into this particular field.

Now, his proposed experiment was the beginning of the Los Alamos fusion program, and that effort, with the Princeton work, really started our national fusion endeavor.

While Tuck and some of his people had a role in the early days in assisting the weapons development, the magnetic confinement fusion program was later split off and became unclassified, which I think was a very good thing.

The fusion research program at Los Alamos concentrated then as it does today on alternatives to the mainline concepts whose engineering embodiment we are today considering. Now, the program at General Atomic is in some ways like the research program at our national laboratories, but it has one significant difference: it is steadily and clearly oriented toward the earliest possible application of fusion power.

Since being at General Atomic, my own perspective has certainly broadened. The program at General Atomic is truly unique in that it bridges the gap between the national laboratory and the industrial sector. I hope my experience and that of my colleagues at General Atomic will be of use to you in deciding on the best means for bridging that gap in the interest of a national commitment to fusion power.

Fusion research in the last quarter century has brought us a long way. Today I believe we are at an important transition point. While the basic physics work is certainly not complete, the fusion program has nonetheless progressed to the point where the emphasis can be shifted to an engineering perspective. The question we face is how to best make that transition.

Until now, the national fusion program has been carried out predominantly in the national laboratories and the universities. That is where most of the fusion knowledge rests today. Commercial fusion power will not arrive without the leadership of the industrial sector. The Center for Fusion Engineering and the devices that will be brought under its auspices, such as the Fusion Engineering Device, can provide the mechanism for transferring fusion technology from a university and national laboratory setting to an industrial base.

From my own standpoint, I believe I should emphasize three prerequisites for that transfer. First and foremost, there must be a strong national commitment to the engineering development phase of fusion. It must transcend party lines and changing administrations. The effort will take many years and will simply languish if it is to start and stop on a 2-, 4-, or 8-year cycle. We have a good example before us in the fusion program of Japan, with which we are very closely associated. This program has gone forward continuously despite changes in Government and political structures. Japan

has in place a national plan to obtain the long-term benefits of fusion power for the Japanese nation. So should we. The Magnetic Fusion Energy Engineering Act of 1980 is the first statement of that commitment. This Congress can solidify the foundation that the Act has laid.

The second prerequisite is the availability of a strong industrial leadership for the program. The management talent and the systems experience in American industry are essential to bring about the commercialization of fusion power. I am certain that other industrial spokespeople present today will attest that the required talent exists and that industry is ready to accept the challenge.

The initial steps of the Department of Energy and the national laboratories in contracting for industrial assistance in building the current generation of fusion experiments show a rising curve of industrial involvement, ranging from the smallest manufacturer of superconducting wire to the largest aerospace companies. This trend should be maintained.

The third prerequisite, then, is the one requiring the most attention. If we are to be successful, we must develop in the most creative way possible the various means of tapping the knowledge in the national laboratories and universities and transferring that knowledge to industry. The talent in the national labs cannot simply be assigned as consultant to a new industrial leadership; rather, key elements of the program must remain with the national laboratories while other key elements must be given to industry. The Center for Fusion Engineering and the Fusion Engineering Device organizations must foster the closest cooperation among the Nation's fusion experts, giving industrial participants responsibility and scope for the development of the engineering leadership that will be required for commercialization of fusion power.

I want thus to contribute my voice in support of your deliberations as they are directed to carrying out the intent of the legislation and building a national commitment to fusion. I would like to urge the Representatives here today and the Congress as a whole to continue their leadership role in broadening America's energy base through the exploitation of fusion by setting up the strongest possible program and attracting to it the Nation's best industrial leadership in partnership with the Government and its national laboratories.

[The prepared statement of Dr. Harold M. Agnew follows:]

STATEMENT OF HAROLD M. AGNEW, PRESIDENT, GENERAL ATOMIC CO.

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It is from an interesting perspective that I come before you to testify today. Several years ago I retired as Director of the Los Alamos Scientific Laboratory. It is an interesting bit of history that in 1950 I was in the LASL Director's office and advised the director that we should enter into a field which the late James Tuck had proposed. His proposed experiment was the beginning of the LASL fusion program and that effort, with Princeton work started our national fusion endeavor. The fusion research program at Los Alamos concentrated on alternatives to the main-line concepts whose engineering embodiment we are now considering. The program at General Atomic is in some ways like the research program at a national laboratory. But it has one significant difference: it is steadily and clearly oriented toward the earliest possible application of fusion power. Since being at General Atomic my own perspective has broadened. The program at General Atomic is truly unique in that it bridges the gap between the national laboratory and the industrial sector. I hope my experience and that of my colleagues at General Atomic will be of use to you in deciding on the best means for bridging that gap in the interests of a national commitment to fusion power.

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opment of the engineering leadership that will be required for commercialization of fusion power.

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Mr. REICHLER. Thank you, Harold.

Next we have Mr. Fred Maxwell, President of Boeing Engineering & Construction Co.

STATEMENT OF FREDERICK W. MAXWELL

Mr. MAXWELL. Mr. Chairman, I am pleased to have the opportunity to address your panel on the subject of the engineering phase of fusion.

You may question why Boeing's views merit your consideration, since we are not a current participant in the national fusion program. We are a very interested party because our principal products require a special fraction of the Nation's energy. Hence, we endorse strong, sustained efforts to assure future U.S. energy supply. We are an informed party through current involvements in most of the other energy development programs, including petroleum production, coal and nuclear power development, nuclear fuel enrichment, the breeder program, and solar and wind energy development.

Finally, we believe we have qualifications derived from management of major high-risk development programs and from some very hard experience in moving projects from the development phase to commercial production.

The current encouraging posture of the fusion program has been reached through sustained and significant Government support and the dedication of first-rate talent in this country and abroad. The program has benefited from an unusually free flow of ideas between major programs in Europe, Russia, Japan, and the United States. We concur that we are now at a most significant point in the program. There is now a unified scientific judgment that an ignited fusion plasma can be produced.

The need to transition from a program based on scientific research and development to one which includes major engineering objectives has been endorsed by the knowledgeable scientific community, the Congress, and the Department of Energy. This consensus among the scientific community, industry, and the Congress is noteworthy at a time when so many other major new endeavors being considered by these forums do not enjoy such consensus or acceptance. The engineering objectives have been set forward in the Magnetic Fusion Energy Engineering Act of 1980. The program mandated by the act is ambitious. It will obviously require continued significant funding and the introduction of additional engineering and program management talents.

As others have said, the magnetic fusion program is now primarily centered in the national laboratories and the universities. This is reflected in part in the composition of the Technical Management Board which is guiding the conceptualization of the Fusion En-

gineering Device, or the FED. Of the 15 persons forming the current board and its subordinate committees, I believe only 2 are from industry. There are good reasons for stronger industrial participation as the engineering phase of the program is entered.

Industry has demonstrated the ability to bring high technology systems to successful commercial application. In fact, that is kind of a truism, and this is seldom achieved without industry involvement.

The engineering phase of an FED will be a long, technically complex, and costly undertaking. Industry has experience in managing such programs. This experience is something that would be particularly valuable in a program where technical advances are being made simultaneously with the ongoing design of the FED. Strict disciplines will have to be introduced to control the configurations of the ultimate device. The early date set for the operation of the device, if maintained, will require stringent control of schedules and planning. Important tradeoffs among performance, schedule, and costs should increasingly consider the ultimate marketplace.

The engineering phase of fusion is a transition phase. The management of the FED should be project-oriented. The tasks set forward should be explicitly defined and finite. Industry traditionally works in this mode and is familiar with the periodic processes of project buildup and demanning.

Industrial involvement in the management of the FED will bring more to the program than a cadre of experienced project managers. It will provide the program with direct access to the broad engineering capabilities of the parent companies should critical needs arise.

Industry will necessarily be involved in such major program tasks as the detailed design and the construction of the fusion engineering device and the design and fabrication of the chosen major subassemblies. It is appropriate that strong industrial input be provided up front to the procurement specifications and the programmatic planning prior to important procurements.

I submit that industrial program management and engineering integration can provide a strong and necessary voice in support of the engineering program in working with the Government to insure adequate program support and funding. A very broad constituency will certainly be required to sustain a program which faces 20 years of expensive engineering development.

Now, my previous comments relate almost entirely to the FED, and I think that these comments probably are in the mainstream of thought of my associates here today. In my following comments, I expect to be in the minority.

Speaking personally, I am less certain of the character of the Center for Fusion Engineering. Provided that strong industry program management is implemented for the Fusion Engineering Device, it is not obvious that early separate establishment of a CFE is necessary or desirable. To the contrary, it may be only semantics if we consider the management of the FED as the primary and perhaps, for now, the only task of the CFE.

What I do urge is that progress on the FED and the establishment of strong management therefore not be delayed by the inevitable political differences of opinion associated with what a CFE in

its full scope should be. I submit that lessons learned and facts determined in establishing the FED and getting on with it may be valuable in ultimately resolving the CFE issue.

To summarize, progress in the magnetic fusion program is encouraging. The program has been well managed, and a strong scientific and technical base exists primarily within universities and national laboratories. A decisive step forward into the engineering phase has been mandated, and increased industrial involvement is essential.

Boeing supports the fusion program and the basic purpose of the Magnetic Fusion Energy Engineering Act of 1980. We are prepared to continue to support and to participate in any aspect where our experience and capability can be of value.

[The prepared statement of Frederick Maxwell follows:]

Testimony to the Fusion Advisory Panel

F.W. Maxwell - June 29, 1981

Mr. Chairman, I am pleased to have the opportunity to address your panel on the subject of the Engineering Phase of Fusion.

You may question why Boeing's views merit your consideration, since we are not a current participant in the national fusion program. We are an interested party because our principal products require a special fraction of the nation's energy; we endorse strong, sustained efforts to assure future U.S. energy supply. We are an informed party through current involvements in most of the other energy development programs (including petroleum production, coal and nuclear power development, nuclear fuel enrichment, the breeder program, and solar and wind energy development). Finally, we have qualifications derived from management of major high risk development programs and from hard experience in moving projects from the development phase to commercial production.

o Fusion has for a long time offered the hope of providing energy from a virtually inexhaustible and globally accessible source of fuel, safely and with minimal environmental impact. In the last few years, major progress has been made in establishing the scientific feasibility of fusion. The plasma parameters required to product net fusion energy have separately been obtained. The size, and hence cost, of prospective Tokamak reactors has been significantly reduced. Alternate fusion concepts show promise.

o The current encouraging posture of the fusion program has been reached through sustained and significant government support and the dedication of first rate talent in the U.S. and abroad. The program has benefited from an unusually free flow of ideas between the major programs in Europe, Japan, Russia, and the United States. We are now at a most significant point in the program. There is now a unified scientific judgment that an ignited fusion plasma can be produced.

o The need to transition from a program based on scientific research and development to one which includes major engineering objectives has been endorsed by the knowledgeable scientific community, the Congress, and the Department of Energy. This ^{consensus} consensus, among the scientific community, industry, and the Congress, is noteworthy at a time when so many other major new endeavors being considered by these forums do not enjoy such acceptance. The engineering objectives have been set forward in the Magnetic Fusion Engineering Act of 1980. The program mandated by the Act is ambitious. It will require continued significant funding and the introduction of additional engineering and program management talent.

o The magnetic fusion program is now primarily centered in the national laboratories and universities. This is reflected in the composition of the Technical Management Board which is guiding the conceptualization of the Fusion Engineering Device. Of the fifteen persons forming the Board and its subordinate committees, only two are from industry. There are good reasons for stronger industrial participation as the engineering phase of the program is entered.

o Industry has demonstrated the ability to bring high technology systems to successful commercial application. In fact, this is seldom achieved without industry.

o The engineering phase will be long, technically complex, and costly. Industry has experience in managing such programs. This experience will be particularly valuable in a program where technical advances are being made as the design of the Fusion Engineering Device proceeds. Strict disciplines will be required to control the configurations of the device. The early date set for the operation of the device will require stringent control of schedules. Important trade-offs among performance, schedule, and cost should increasingly consider the ultimate market place.

o The engineering phase of fusion is a transition phase. The management of the Fusion Engineering Device should be project oriented. The tasks set forward should be explicitly defined and finite. Industry traditionally works in this mode and is familiar with the processes of project buildup and demanning.

o Industrial involvement in the management of the Fusion Engineering Device will bring more to the program than a cadre of experienced project managers. It will provide the program with direct access to the broad engineering capabilities of the parent companies should critical needs arise.

o Industry will necessarily be involved in such major program tasks as the detailed design and construction of the Fusion Engineering Device, and the design and fabrication of major subassemblies. It is appropriate that strong industrial input be provided up-front to the procurement specifications and the programmatic planning prior to important procurements.

o Industrial program management and engineering integration can provide a strong and necessary voice in support of the engineering program in working with the government to ensure adequate program support and funding. A broad constituency will be required to sustain a program which faces 20 years of expensive engineering development.

Speaking personally, I am less certain of the character of the Center for Fusion Engineering. Provided that strong industry program management is implemented for the Fusion Engineering Device, it is not obvious that early separate establishment of a CFE is necessary or desirable. Or, to the contrary, it may be just an exercise in semantics to consider the management of the FED as the primary and perhaps, for now, the only task of the CFE.

I do urge that progress on the FED and establishing strong management therefore not be delayed by the inevitable political differences of opinion associated with the full scope CFE. Lessons learned and facts determined in establishing the FED may be valuable in ultimately resolving the CFE issue.

To summarize, progress in the magnetic fusion program is encouraging. The program has been well managed and a strong scientific and technical base exists primarily within the universities and national laboratories. A decisive step forward into the engineering phase of fusion has been mandated. Increased industrial involvement is essential.

Boeing supports the fusion program and the purposes of the Magnetic Fusion Engineering Act of 1980. We are prepared to participate in any aspect where our experience and capability can be of value.

Mr. REICHLE. Thank you, Fred.
Our next speaker is Bob Sherman.

STATEMENT OF ROGER J. SHERMAN

Mr. SHERMAN. Thank you, Mr. Chairman.

I would like to address my comments on the CFE to four questions:

First, is it necessary at this time to develop magnetic confinement fusion?

Second, is the technology ready to move vigorously ahead?

Third, if so, is the CFE the best way to achieve national goals; and

Fourth, how can the CFE best be established?

In the United States, between 1979 and the year 2000, our population is expected to increase by about 39 percent and the civilian labor force by 26 percent. During this period, although, due to conservation and other factors, our energy consumption per constant GNP dollar is expected to decrease by about 18 percent, the total amount of electricity consumed will increase by about 108 percent. This reduction of 18 percent, in comparison with GNP, is on top of an already achieved reduction of 14 percent, when we compare it to 1973 levels.

Conservation can satisfy a part of the requirements, but to maintain our standard of living, to have a competitive position in the industrial world, and to provide jobs for between a million and a million and a half people entering the labor force each year, we will need much more electricity. By the year 2000, electricity probably will supply about 46 percent of the national energy needs.

Between now and 2000, and for some years after that, our only available and reliable sources of central station electricity will be coal and present generation nuclear. The Government will not permit the construction of additional central station powerplants burning gas or oil. Little additional hydro capacity is available, and the "soft" energy technologies are not promising for central station electric generation. The burden of satisfying our needs in the near future will fall on coal and present generation nuclear, and neither of the two can do it alone.

For the longer range, though, after the year 2000, we need options for improved electric generating systems. One option, of course, is that breeder. As a nation, it would be prudent to pursue development of the breeder vigorously. We have lost a lot of time in the last few years in establishing a viable breeder program. However, while one can hope that the breeder will have full public acceptance, there certainly can be no assurance of such acceptance. Therefore, one option is not enough.

A second option, with the potential for safe, reliable, environmentally compatible, low-cost energy from inexhaustible fuel sources, is needed. That second option is fusion. At this point there would appear to be no third option.

There is not time to lose in moving ahead on the fusion option. The year 2000 is 20 years away. It took longer than that to develop the present generation light water reactors to their present state of

commercial operation. Therefore, the next step must be taken promptly, and it must be the right kind of a step.

The Magnetic Fusion Energy Engineering Act of 1980 was passed by an overwhelming majority in the House and by a unanimous vote in the Senate. It became law on October 7, 1980, making it national policy to initiate the engineering phase of fusion development with the expressed purpose of operating a fusion demonstration plant "at the turn of the 21st century."

The International Atomic Energy Agency's workshop in 1979, the ERAB in 1980, and the Atomic Industrial Forum and the Fusion Power Associates in 1981 all expressed the view that magnetic fusion was ready to move ahead vigorously into the "engineering stage."

Moving magnetic confinement fusion into the "next stage" of development involves considerations of, first, what are the objectives of the development? Second, what are the program characteristics? Third, who should manage and technically direct it? And fourth, who should exercise cognizance over it on behalf of the Government?

Among the broad objectives stated in Public Law 96-386 are the following:

* * * To establish national goal of demonstrating the engineering feasibility of magnetic fusion by the early 1990's; * * * to achieve * * * not later than the year 1990 * * * operation of a magnetic fusion engineering device;—to establish as a national goal the operation of a magnetic fusion demonstration plant at the turn of the 21st century; * * * to maintain the United States as the world leader in magnetic fusion.

Our organization believes these objectives are sound and that they could be achieved if a national commitment is made and the necessary funding provided to support the attainment of them. If a national commitment is made and funds provided for magnetic fusion, the probability of success is high.

The goal should not be to achieve the "highest potential" of fusion. This is too diffused a goal, and its pursuit is likely for years to develop R. & D. components, systems, and test facilities, without effective relationship to the goal-oriented projects.

Instead, the goal should be to produce fusion-electric energy which is safe, reliable, environmentally compatible, and hopefully, economically competitive. This is a worthwhile and achievable goal clearly related to our national interests and needs. If we desire, as Public Law 96-386 indicates, "* * * to establish as a national goal the operation of a magnetic fusion demonstration plant at the turn of the 21st century * * *", we should say to ourselves: "What is required to obtain the knowledge and the experience to build such a demonstration plant?"

In general, the program required to achieve this objective is a major fusion device between the demonstration plant, to operate at the turn of the 20th century, and the TFTR, to operate in late 1982. This is widely thought of as a Fusion Engineering Device, to operate in about 1990. The Technical Management Board at Oak Ridge has defined a preliminary conceptual design of the FED. What is needed now is a permanent mechanism for accomplishing the FED's final conceptual design, its goal-oriented supporting R. & D., its systems engineering, detailed design engineering, procure-

ment of materials and equipment, installation and assembly, start-up and test, operation, and the design and construction of various supporting facilities.

Ebasco believes the best way to carry out a program aimed at the objective of developing fusion into a viable option is to establish a CFE and place responsibility for its management and technical direction squarely on an industrial company or team of industrial companies competitively selected on the basis of qualifications and experience, and not one selected on a noncompetitive basis or on the basis of willingness to make the largest financial contribution, since this contribution at best could not be a very significant portion of the Government's cost.

Government-funded laboratories such as Princeton Plasma Physics Laboratory, Lawrence Livermore National Laboratory, Oak Ridge National Laboratory, Argonne, Los Alamos, together with a few universities, have done an outstanding job in developing the science and basic technology of magnetic fusion.

However, with TFTR, it was recognized that the required systems engineering, the size and complexity of components, and the difficulties of installation and assembly were of such a magnitude that major industrial involvement was required. Ebasco was the industrial subcontractor responsible to PPPL for redefinition of the conceptual design, detailed design engineering, procurement of materials and equipment, installation and assembly of the TFTR.

In this effort, we have been assisted by Grumman Aerospace as a subcontractor on our project team, and by such major manufacturers as Westinghouse, Rockwell, Allis-Chalmers, Brown-Boveri, and Combustion Engineering, to name just a few.

Although this project has experienced the usual kinds of difficulties in a first-of-a-kind development project, the job is going very well. The project is within 8 months of original schedule and within 14 percent of estimate. We feel that this is an extraordinary example of this type of project and a tribute to the combination of laboratory and industrial contractor concept.

However, since the FED objective is to advance the concept close to commercialization, we also believe it is time to maximize the industrial participation in it beyond what has been done previously while still utilizing input from all of the National Laboratories that would have a significant contribution to make.

And this would assist in getting industry ready for the commercialization stage.

Inasmuch as the next stage of fusion development, the FED, inevitably must be funded by the Government, it is essential that the Government maintain cognizance over the program. This should comprise complete technical monitoring, including the obtaining of technical input from the Labs and discussion with the Labs, and it should include financial control in the sense of budgeting and auditing, but not management or technical direction.

We visualize that the CFE would have as its mission to manage and technically direct the activities of the CFE;

Develop the CFE program;

Specify the site requirements for an FED, and manage the site;

Select the contractor or contractors to manage and technically direct the engineering, design, procurement, and installation of the FED and of supporting structures;

Monitor performance of the FED contractor or contractors;

Operate the FED and other devices and facilities located at the CFE;

Plan and direct a program of fusion engineering and analysis;

Plan and direct a program for the development of fusion engineering technology;

Subcontract to industry to the fullest extent feasible supporting development and technology tasks;

Maintain cognizance over safety, environmental, and QA aspects of the CFE program;

Maintain active liaison with National Laboratories and universities, and encourage their involvement on both an advisory basis and on a task-assignment basis; and

Maintain active liaison with the electric utility industry, encourage their involvement as potential end-product users of fusion reactors.

The organization selected to staff and operate the CFE should also be able to provide:

A sound CFE program, starting from the program now being developed by DOE;

A sound CFE organization structure;

Home office responsibility, involvement and support of the group;

A strong and experienced CFE director;

A strong and experienced CFE management staff and technical staff;

Fusion community advice and assistance by having universities and National Laboratories perform task assignments and also to serve on R. & D. Advisory Board;

End-product user advice and assistance by having electric utility representatives serve on an electric utility advisory board; and

Broadly based industrial participation by subcontracting materials, equipment, component and systems work to many companies.

Finally, we urge that the Government, early in fiscal 1982, issue a request for proposal for an industrial company or team of companies to establish and to manage and to technically direct a CFE, and that selection be made on the basis of qualifications and experience.

Thank you.

[The prepared statement of Roger J. Sherman follows:]

STATEMENT OF ROGER J. SHERMAN, CHAIRMAN, BOARD OF DIRECTORS, EBASCO SERVICES, INC.

My name is R. J. Sherman, Chairman of the Board of Directors of Ebasco Services Incorporated.

I am here to comment on the proposed Center for Fusion Engineering (CFE). My thoughts will be addressed to the questions:

- (a) Is it necessary at this time to develop magnetic confinement fusion?
- (b) Is the technology ready to move vigorously ahead?,
- (c) If so, is a CFE the best way to achieve national goals, and
- (d) How can a CFE best be established?

Is It Necessary to Develop Fusion?

In the United States, between 1979 and the Year 2000, our population is expected to increase by 39 per cent and our civilian labor force by 26 per cent. During this period, although due to conservation and other factors, our energy consumption per GNP dollar is expected to decrease by about 18 per cent, the amount of electricity consumed will increase by about 108 per cent. This reduction of 18% is on top of an already achieved reduction of 14%.

Conservation can satisfy only a part of our requirements. To maintain our American standard of living, to have a competitive position in the industrial world, and to provide jobs for 1-1.5 million young people entering the labor force each year we will need much more electricity. By Year 2000, electricity probably will supply 46 per cent of our total energy needs.

Between now and 2000 (perhaps for some years after that), our only available and reliable sources of central station electric generation are coal and present-generation nuclear. The Government will not permit the construction of additional central station power plants burning oil or gas. Little additional hydro capacity is available, and the "soft" energy technologies are not promising for central station electric generation. The burden of satisfying our needs in the near future will fall on coal and present generation nuclear, and neither can do it alone.

For the longer range, i. e. after year 2000, we need options for improved electric generating systems. One option, of course, is the breeder reactor. As a nation, it would be prudent to pursue development of the breeder vigorously. We have lost much time during the last few years in establishing a viable breeder program, and we should get on with the job. However, while one can hope the breeder will have full public acceptance, there is no assurance of such acceptance. Therefore, one option is not enough. A second option with the potential for safe, reliable, environmentally-compatible, low-cost energy from inexhaustible fuel resources is needed. That second option is fusion. At this point, there would appear to be no third option.

There is no time to lose in moving ahead on the fusion option. The Year 2000 is less than 19 years away. It took longer than that to develop present-generation Light Water Reactors to their current state of commercial operation. The next step must be taken promptly and it must be the right kind of a step.

Is Fusion Ready to Move Ahead?

The Magnetic Fusion Energy Engineering Act of 1980 (PL 96-386) was passed by an overwhelming majority in the House and by a unanimous vote in the Senate. It became law on October 7, 1980, making it national policy to initiate the engineering phase of fusion development with the expressed purpose of operating a fusion demonstration plant "at the turn of the twenty-first century." The Congress acted decisively, and had a sound basis for its action.

The International Atomic Energy Agency's workshop in 1979, the Energy Research Advisory Board (ERAB) in 1980, and the Atomic Industrial Forum and the Fusion Power Associates in 1981 all expressed the view that magnetic fusion was ready to move ahead vigorously into the "engineering stage." The ERAB stated:

"The magnetic fusion program can, and should, embark on the next logical phase toward its goal of achieving economic feasibility of magnetic fusion. To this end, a broad program of engineering experimentation and analysis should be undertaken under the aegis of a center for Fusion Engineering (CFE)."

Is a CFE The Best Way to Achieve National Goals?

Moving magnetic confinement fusion into the "next stage" of development involves considerations of (a) what are the objectives of the development, (b) what are the program characteristics, (c) who should manage and technically direct it, and (d) who should exercise cognizance over it on behalf of the Government?

Objectives. Among the broad objectives stated in PL 96-386 are the following

"...to establish a national goal of demonstrating the engineering feasibility of magnetic fusion by the early 1990's;...to achieve... not later than the year 1990,...operation of a magnetic fusion engineering device;---to establish as a national goal the operation of a magnetic fusion demonstration plant at the turn of the twenty-first century;...to maintain the United States as the world leader in magnetic fusion."

Ebasco believes these objectives are sound and that they could be achieved if a national commitment is made and necessary funding provided to support the attainment of them. We went to the moon in 10 years. If a national commitment is made and funds provided for magnetic fusion, the probability of success is high.

The goal should not be to achieve "the highest potential" of fusion. That is too diffused a goal, and its pursuit is likely for years to develop R&D-type components, systems and test facilities, without effective relationship to goal-orientated projects.

Instead, the goal should be to produce fusion-electric energy which is safe, reliable, environmentally compatible, and economically competitive.

This is a worthwhile and achievable goal clearly related to our vital national interests and needs. If we desire, as PL 96-386 indicates, "...to establish as a national goal the operation of a magnetic fusion demonstration plant at the turn of the twenty-first century...", we should say to ourselves "what is required to obtain the knowledge and experience to design and build such a Demo plant?"

Program. In general, the program required to achieve this objective is a major fusion device between the Demo plant (to operate at the turn of the 20th century) and the TFTR (to operate in late 1982). This is widely thought of as a Fusion Engineering Device (to operate about 1990.) The Technical Management Board at Oak Ridge has defined a preliminary conceptual design of the FED. What is needed now is a permanent mechanism for accomplishing the FED's final conceptual design, it's goal-oriented supporting R&D, it's systems engineering, detailed design engineering, procurement of materials and equipment, installation and assembly, start-up and test, operation, and the design and construction of supporting facilities.

Management and Technical Direction. Ebasco believes that the best way to carry-out a program aimed at the objective of developing fusion into a viable option for the production of electric energy is to establish a CFE and place responsibility for its management and technical direction squarely on an Industrial Company or Team of Industrial Companies competitively selected on the basis of qualifications and experience (not one selected on a non-competitive basis or on the basis of willingness to make the largest financial contribution.)

Government-funded laboratories such as the Princeton Plasma Physics Laboratory (PPPL), the Lawrence Livermore National Laboratory (LLNL), the Oak Ridge National Laboratory (ORNL), the Argonne National Laboratory (ANL) and the Los Alamos National Laboratory (LANL), together with a few universities have done an outstanding job in developing the science and basic technology of magnetic fusion. However, with TFTR, it was recognized that the required systems engineering, the size and complexity of components, and the difficulties of installation and assembly were of such magnitude that major industrial involvement was required. Ebasco was selected as the industrial subcontractor responsible to PPPL for redefinition of the conceptual design, detailed design engineering, procurement of materials and equipment, installation and assembly of the TFTR. In this effort, we have been assisted by Grumman Aerospace as a subcontractor on our project team, and by such major equipment manufacturers as Westinghouse, Rockwell International, Allis-Chalmers, Brown-Boveri, Combustion Engineering and others, to name some.

Although we have experienced the usual kind of difficulties in a first-of-a-kind development project, the job is going well. The project is within eight months of original schedule and within 14% of estimate -- we feel this is an extraordinary result for this type project and a tribute to the combination of laboratory and industrial contractor concept. However, since the FED objective is to advance the concept close to commercialization, we also believe it is time to maximize the industrial participation in it beyond what has been done previously while still utilizing the input from all of the National Laboratories that would have contributions to make.

Government Cognizance. Inasmuch as the next stage of fusion development, i. e. the FED, inevitably must be funded by the Government, it is essential that the Government maintain cognizance over the program. This should comprise technical monitoring, including the obtaining of technical "input" from the Labs and discussion with them, and it should include financial control in the sense of budgeting and auditing--not management and technical direction.

How Can CFE Best Be Established?

We visualize that the CFE would have as its mission to:

- 1 - Manage and technically direct the activities of the CFE.
- 2 - Develop the CFE Program.
- 3 - Specify the site requirements for an FED, and manage the site.

- 4 - Select a contractor to manage and technically direct the engineering, design, procurement, and installation of the FED and of supporting buildings and facilities.
- 5 - Monitor performance of the FED contractor.
- 6 - Operate the FED and other devices and facilities located at the CFE.
- 7 - Plan and direct a program of fusion engineering and analysis.
- 8 - Plan and direct a program for the development of fusion engineering technology.
- 9 - Subcontract to industry to the fullest extent feasible supporting development and technology tasks.
- 10 - Maintain cognizance over safety, environmental and QA aspects of the CFE program.
- 11 - Maintain active liaison with national laboratories and universities, and encourage their involvement on both an advisory basis and on a task-assignment basis.
- 12 - Maintain active liaison with the electric utility industry, encourage their involvement as potential end-product users of fusion reactors.

The organization selected to staff and operate the CFE should be able to provide:

- "1 - A sound CFE Program (starting from the program now being developed by DOE).

- 2 - A sound CFE organization structure.
- 3 - Home office responsibility, involvement and support.
- 4 - A strong and experienced CFE Director.
- 5 - A strong and experienced CFE Management staff and Technical staff.
- 6 - Fusion community advice and assistance by having universities and national laboratories perform task assignments and serve on R&D Advisory Board.
- 7 - End-product user advice and assistance by having Electric Utility representatives serve on an Electric Utility Advisory Board.
- 8 - Broadly-based industrial participation by sub-contracting materials, equipment, component and systems work to many companies."

Finally, we urge that the Government, early in FY-1982 issue a Request for Proposal (RFP) for an industrial company or team of companies to establish and to manage and technically direct a CFE, and that selection be made on the basis of qualifications and experience.

Mr. REICHLER. Thank you, Bob.
Next, Larry Mead.

STATEMENT OF LAWRENCE M. MEAD, JR.

Mr. MEAD. Mr. Chairman, members of the special panel, I am Lawrence M. Mead, senior vice president responsible for Engineering for Grumman Aerospace Corp.

As an industrial participant within the Magnetic Fusion Energy Program we welcome this opportunity to present our views on the CFE/FED program, particularly our concerns on industry's role.

My presence here today, along with the fact that our president, Mr. Joseph Gavin, is a member of your panel—he is sorry he could not be with you today—and our presidential assistant for corporate technology, Mr. Ira G. Hedrick's membership on the Fusion Power Coordinating Committee bear witness to the Grumman Co.'s commitment to fusion.

We believe this source of energy with its limitless supply of easily accessible fuel is of strategic importance not only for the developed nations, but also for the less developed countries. Fusion power has the potential of being a major factor in reducing world tensions.

Under the most aggressive of planning scenarios, it will take 20 years to bring fusion to the power demonstration stage. For the United States to maintain its leadership role in fusion during this period and to emerge in a favorable competitive position worldwide in the 21st century, it is important that the fusion development program be given all the resources necessary, and that industry's role be expanded during this development phase not only to utilize the management and systems discipline developed in the sixties and seventies for large-scale R. & D. programs but also most importantly, to prepare industry for the major production effort on operational fusion powerplants.

It will be 25 to 30 years before fusion becomes a commercial enterprise. The development risks are very high, but with a strong commitment from our Government, industry is willing to make commitments now—witness as one small example the some \$4 to \$5 million of corporate moneys already invested by the industrial participants, including Grumman, in just one study, that for the "Elmo Bumpy Torus Proof of Principle Device."

My own company has invested considerably more than that in its fusion endeavors and, perhaps even more important, is our investment of our experienced and highly skilled personnel.

In the past year industry has received strong signals of encouragement from Washington; namely, the findings of the Fusion Review Panel of the Energy Research Advisory Board [ERAB] and the Magnetic Fusion Energy Engineering Act of 1980.

The ERAB panel stated, and I quote:

The Panel is firmly of the view that the development of the requisite engineering experience requires a broad program of engineering experimentation and analysis having at its focus a test device with a burning, even an ignited, plasma.

Then going on,

... It is important that the TFTR, presently under construction by PPPL, be exploited as early as possible. The U.S. Fusion Program is ready, in our view, to embark on such an engineering program.

The ERAB panel also recommend that DOE should establish a Center for Fusion Engineering [CFE] operated by a strong, single-line management and that CFE should undertake the procurement responsibility for the design and construction of the Fusion Engineering Device [FED]. We at Grumman strongly endorse these concepts and the Magnetic Fusion Energy Engineering Act of 1980.

Before giving you my remarks on the CFE and FED, allow me to discuss our company's involvement in fusion to date and some of the pertinent experience that could be brought to bear in the future.

Grumman began its involvement in the fusion reactor program in 1975, when, teamed with Ebasco we successfully competed for design and fabrication of the Tokamak fusion test reactor [TFTR]. The TFTR is the first reactor scale fusion device and the first U.S. fusion project with major industrial participation.

Since that time Grumman has expanded its fusion posture becoming involved with all the major Government laboratories and universities. Our efforts have spanned the gamut of the magnetic fusion program including program planning, system studies and designs, technology development, and basic fusion science.

Prior to that Grumman had a considerable R. & D. effort in the area of plasma physics, magnetohydrodynamics, superconducting magnets, and nuclear technologies, all directly applicable to fusion power.

From the beginning of the TFTR design effort the program has benefited by adopting the management and system disciplines of large industry. As examples, performance measuring system [PMS] for cost and schedule control, and a configuration and change control system for control of the evolution of the final design, all these are standard procedures in our company as well as many others.

On TFTR we have provided the systems engineering resources and discipline to integrate the requirements for all the reactor systems: Magnetic, electrical, vacuum, diagnostic, remote handling, et cetera. We are also under contract for system engineering for the FED conceptual design studies currently being conducted at Oak Ridge.

As an example of our involvement in the technology area, Grumman has developed a number of devices for use in the maintenance of highly radiative machines. These include handling devices and remotely operated cutters to enable removal of sections of the toroidal vacuum chamber.

We have designed and will build a tritium cleanup system for Los Alamos' Tritium System Test Assembly, which is a critical link in the design of future tritium-fueled reactors. X-ray diagnostics, designed and built by Grumman, are operated on three major fusion experimental devices.

Via this wealth of systems and technology participation we have identified key areas requiring engineering development and have commenced programs in these areas; namely, more efficient neutral beam heating systems; RF heating systems; impurity control; plasma control; tritium handling; maintenance procedures, materi-

als development; manufacturing techniques; testing procedures, and steady state versus pulsed operation, just to name a few.

Time does not allow my discussing these experiences any further, but to sum up, let me say that Grumman has approximately 250 engineers and scientists with fusion experience at this time. We are committed to the program and believe that these people with experience in fusion represent a national resource which should be nurtured and taken advantage of. What we need now is a commitment from DOE to move ahead to the next step.

Now let me return to the CFE/FED issue. Garnered from our participation in the TFTR, FED and other fusion programs we have developed a sound understanding of the magnitude and complexities of the task required to bring fusion to the demonstration phase. Grumman along with other industries has recommended the establishment of an organization to cope with these complex tasks.

We are a member of the AIF's Committee on Fusion, and as such was a participant in the writing of their document "A Report on the Organization and Management of Fusion Engineering," already summarized by Mr. Sidney Law. I understand that copies of this report will be distributed here today. We strongly endorse the findings given in this report.

I would just like to briefly reiterate a couple of the more important points:

We believe a commitment to the CFE is important and the time is now.

Siting of the CFE should be given a priority.

The CFE management should have responsibility for developing the requirements for the projected FED and for selecting on a competitive basis, a prime industrial contractor for the design, construction, and installation of the FED at the CFE site.

The CFE management should be precluded from bidding on the prime contract for design and construction of the FED, but should be permitted to bid on subcontracts involving the manufacture of system components.

Industry, via the AIF's Fusion Committee, has debated without Government involvement the CFE/FED issue for approximately half a year, its findings being expressed in the AIF report. A number of options have been suggested.

We recommend that an industry/government task group be appointed to jointly:

Develop criteria for the CFE, including the scope of its activities, its responsibilities, and its authority; and that they should determine the approach to be taken, based on these criteria, for organization of the center and the selection of its management.

[The prepared statement of Lawrence M. Mead, Jr. follows:]

STATEMENT OF LAWRENCE M. MEAD, JR., SENIOR VICE PRESIDENT—ENGINEERING,
GRUMMAN AEROSPACE CORP., BETHPAGE, N.Y.

INTRODUCTION

Mr. Chairman, Members of the Special Panel, and Members of Congress, I am Lawrence M. Mead, Senior Vice-President responsible for Engineering for Grumman Aerospace Corporation. As an industrial participant within the Magnetic Fusion Energy program, we welcome this opportunity to present our views on the CFE/FED program, particularly our concerns on industry's role. My presence here today along with our President, Mr. Joseph Gavin's membership on this Advisory Panel on Fusion Energy, and our Presidential Assistant for Corporate Technology, Mr. Ira G. Hedrick's membership on the Fusion Power Coordinating Committee bear witness to the Grumman Company's commitment to Fusion. We believe this source of energy with its limitless supply of easily accessible fuel is of strategic importance not only for the developed nations, but also for the less developed countries. Fusion power has the potential of being a major factor in reducing world tensions.

Under the most aggressive of planning scenarios, it will take 20 years to bring fusion to the power demonstration stage. For the US to maintain its leadership role in Fusion during this period and to emerge in a favorable competitive position world wide in the 21st century, it is important that the fusion development program be given all the resources necessary, and that industry's role be expanded during this development phase not only to utilize the management and systems discipline developed in the 60's and 70's for large scale R&D programs but also to prepare industry for the major production effort on operational fusion power plants.

It will be 25-30 years before fusion becomes a commercial enterprise. The development risks are very high, but with a strong commitment from our government, industry is willing to make commitments now - witness the some 4-5 million dollars of corporate monies already invested by the industrial participants (including Grumman) in just one study, that for the Elmo Bumpy Torus Proof of Principle Device. My own company has invested considerably more than that in its fusion endeavors and, perhaps even more important, is our investment of our experienced and highly skilled personnel.

In the past year industry has received strong signals of encouragement from Washington, namely the findings of the Fusion Review Panel of the Energy Research Advisory Board (ERAB) and the Magnetic Fusion Energy Engineering Act of 1980. The ERAB panel stated, and I quote, "The Panel is firmly of the view that the development of the requisite engineering experience requires a broad program of engineering experimentation and analysis having at its focus a test device with a burning, even an ignited, plasma. - - - - -", it is important that the TFTR, presently under construction by PPPL, be exploited as early as possible. The US Fusion program is ready, in our view, to embark on such an engineering program."

They also recommend that DoE should establish a Center for Fusion Engineering (CFE) operated by a strong, single-line management and that CFE should undertake the procurement responsibility for the design and construction of the Fusion Engineering Device (FED). We at Grumman strongly endorse these concepts and the Magnetic Fusion Energy Engineering Act of 1980.

Before giving you my remarks on the CFE and FED, allow me to discuss our company's involvement in Fusion to date and some of the pertinent experience that could be brought to bear in the future.

Grumman Experience

Grumman began its involvement in the Fusion Reactor Program in 1975, when, teamed with Ebasco Services, we successfully competed for design and fabrication of the Tokamak Fusion Test Reactor, TFTR. The TFTR is the first reactor scale (\$300M) fusion device and the first US fusion project with major industrial participation. Since that time Grumman has expanded its fusion posture becoming involved with all the major government laboratories and major universities. Our efforts have spanned the gamut of the Magnetic Fusion Program including: program planning, system studies and designs, technology development, and basic fusion science. Prior to that in the late 1950's and throughout the 60's Grumman had a considerable R&D effort in the area of plasma physics, magnetohydrodynamics, superconducting magnets, and nuclear technologies - all directly applicable to fusion power.

From the beginning of the TFTR design effort the program has benefited by adopting the management and system disciplines of large industry, such as a Performance Measuring System (PMS) for Cost & Schedule Control, and a Configuration and Change Control System for control of the evolution of the final design.

On TFTR we have provided the Systems Engineering resources and discipline to integrate the requirements for all the reactor systems; magnetic, electrical, vacuum, diagnostic, remote handling, etc. We are also under contract for system engineering for the FED conceptual design studies currently being conducted at ORNL.

As an example of our involvement in the technology area, Grumman has developed a number of devices for use in the maintenance of a highly radiative machine. These include handling devices and remotely operated cutters to enable removal of sections of the toroidal vacuum chamber. We have designed and will build a tritium clean up system for Los Alamos' Tritium System Test Assembly (TSTA) - which is a critical link in the design of future tritium fueled reactors. X-ray diagnostics, designed and built by Grumman, are operated on three major fusion experimental devices.

Via this wealth of systems and technology participation we have identified key areas requiring engineering development and have commenced programs in these areas namely: more efficient neutral beam heating systems; RF heating systems; impurity control; plasma control; tritium handling; maintenance procedures, materials development; manufacturing techniques; testing procedures, and steady state vs pulsed operation.

Time does not allow my discussing these experiences any further, but to sum up, let me say that Grumman has approximately 250 engineers and scientists with fusion experience at this time. We are committed to the program and believe that these people with experience in fusion represent a national resource which should be nurtured and taken advantage of. What we need now is a commitment from DoE.

Now let me return to the CFE/FED issue. Garnered from our participation in the TFTR, FED and other fusion programs we have developed a sound understanding of the magnitude and complexities of the task required to bring fusion to the demonstration phase. Grumman along with other industries has recommended the establishment of an organization to cope with these complex tasks.

Grumman is a member of the AIF's Committee on Fusion, and as such was a participant in the writing of the AIF's document "A Report on the Organization and Management of Fusion Engineering", dated January 20, 1981. I understand that copies of this report will be distributed here today. We strongly endorse the findings given in this report.

I will just briefly reiterate some of the most important findings:

- o We believe a commitment to the CFE is important and the time is now.
- o Siting of the CFE should be given a priority.
- o The CFE management should have responsibility for developing the requirements for the projected FED and for selecting on a competitive basis, a prime industrial contractor for the design, construction, and installation of the FED at the CFE site.
- o The CFE management should be precluded from bidding on the prime contract for design and construction of the FED, but should be permitted to bid on subcontracts involving the manufacture of system components.

Industry, via the AIF's Fusion Committee, has debated without government involvement the CFE/FED issue for approximately half a year, its findings being expressed in the AIF report. A number of options have been suggested. We recommend that an industry/government task group be appointed to jointly:

- Develop criteria for the CFE, including the scope of its activities, its responsibilities, and its authority.
- Determine the approach to be taken, based on these criteria, for organization of the Center and selection of its management.

Mr. Chairman, this concludes my prepared remarks. I would be pleased to try to answer any questions.

Mr. REICHLER. Thank you, Larry.

Now, in the panel before us we have an enormous amount of industrial talent, men who have had substantial experience in running industrial organizations or major parts of them.

I believe three of the four have strongly endorsed the idea of a Center for Fusion Engineering now. One strongly reminds us that we must not lose sight of a strong role for the National Laboratories in the engineering stage of development.

I would like to start the questions by asking how, if we have a Center for Fusion Engineering, we prevent it from becoming a monster, that is, to grow and grow and grow and become an organization that has no bounds in expanding itself?

Mr. SHERMAN. I think that the strong argument for having this industrially managed is just for that purpose. Industrial organizations tend to have a pretty good record on keeping things from becoming a monster, not that they invariably have been able to keep them down to the size that would probably be the most efficient size, but I think industrial history shows that they have stayed away from monsters.

You can't make much money on a monster, and most industrial organizations have to have something on the bottom line.

Mr. MEAD. That's the key to it.

Mr. REICHLER. Do other panel members have questions?

Yes, Ken.

Dr. FOWLER. I would like to pick up on one of the themes you mentioned already, Len. Mr. Maxwell questioned the CFE role, and I would be interested in hearing the opinions of the other three members specifically addressed to that point, and also anything they might wish to comment in respect to the previous panel's comments on the same issue.

Mr. SHERMAN. Of whether there should be a CFE?

Mr. REICHLER. Yes. The point Mr. Maxwell raised.

Mr. MAXWELL. Could I make a clarification? I am not opposed to the purposes of a CFE.

My exception had to do with if the establishment of a CFE, and the consensus which is inevitably required to get it established, causes it to be in the critical path of getting on with an FED, then I think let's tilt only one windmill at a time.

I am not saying that given we get on with the FED program that I question the merit of a CFE.

Dr. FOWLER. I think it is a very serious point that you raise, because I think specifically the issue is which is correct.

Dr. AGNEW. Coming back to the previous question, I would submit that if you have a strong CFE which is dedicated toward the appropriate management in bringing into being the FED, then you will not get a monster.

If you do it the other way, without the CFE, and just have whatever management structure is to build the FED, then they will always be shooting at a moving target. As new ideas come out, you will find satellite jobs springing up; indeed, you will have a super-national industrial laboratory for the development of fusion. The danger is that they will always be playing with their toys, and you will never get done what you set out to do.

So I think that you need the CFE, whose charter is to bring into being that FED, that single objective—although there clearly will be changes as you go down the road, and problems will arise and you will have to change materials or change concepts. I think you need this particular organization.

Mr. McCORMACK. In that respect, Harold, let's assume for a moment that we wanted to bring an FED on line by June 30, 1990, when do you think it is necessary to freeze a final design on a machine such as that?

What I am trying to get at is, how much time do we have to get a CFE in operation to do this job? How much leadtime do we actually have? Can we build a CFE and then say, "Now go out and do an FED," or do we have to do them both at once?

Dr. AGNEW. I guess my concern is that it is not clear which type of FED you are really going to go for.

In the next 2 years I can see some rather remarkable things happening, perhaps, which could change our viewpoint. If you are going to go straight for a tokamak, then I think you can start right away. But there are some other concepts that are looking very attractive.

There is also this question, which I think has not been resolved. Do you really want to go first for the generation of electricity—let me call that "pure"—or do you want to look first at a hybrid? I don't know. There could be arguments given on either side. And I think that, in turn, would determine when you want to start.

Mr. REICHLE. Back to the question Ken Fowler raised, let me ask Bob Sherman this: If we want an FED—again following Mr. McCormack's comment—by 1990, and this is going to be somewhere between \$1 billion and a \$3 billion project, how far do you have to back up to freeze design to allow time for completion of detailed design and construction to get this job done?

Mr. SHERMAN. I would say you would have to back up pretty far. Certainly you would have to freeze design. You need 6 years after a design freeze, I would think, in order to have a reasonable chance of getting this thing done.

Mr. REICHLE. So if you backup from 1990 to 1984, you have got to have your design organization established by when, would you say?

Mr. SHERMAN. Well, you would have to have your design organization, hopefully, established by 1982; 1990, of course, is a very optimistic date in itself.

Mr. REICHLE. Larry, does that conform with your thinking?

Mr. MEAD. Yes; I guess the question really gets back to what is the purpose of the CFE and the FED, and I guess the real purpose is how do we get to useful fusion energy quickest and are we ready to proceed with an FED or do we need the CFE first to figure out what this FED should be, and pull together all of that into a generally agreeable procedure?

So that I guess my own view is that we need the CFE, otherwise, maybe we would go about the wrong FED.

Dr. LANDIS. It still seems to me that we are facing rather enormous institutional problems by setting up something like CFE. Not that I am opposed to it, but I don't know that we have addressed those problems adequately. We talk about bringing industry in. Industry wants to earn a profit, wants to get the job done quickly.

If you have one contractor, one CFE, how do you judge whether he is doing the best job of getting the thing done?

You have no way to compare him against another performer because he is essentially a monopoly.

I am waiting for comments.

Dr. EVANS. Dr. Agnew, if the CFE helps to decide in the next few years which one of these to fly with, is it more complicated to spend all of your time in that organizational effort of proceeding with CFE rather than getting on with the FED organization by 1982?

Dr. AGNEW. Well, I would envision it having two roles. One is to set up the structure so that it can best employ the brains. You know, there are really limited numbers of brains in the country in fusion. There is a lot of arm-waving in a lot of areas, but you look around, and an awful lot of the brains are in this room.

You need to maximize that talent, to get them working together, making sure that they feel as if they are part of the program. After all, most of these people have spent their whole professional careers in fusion, believing in fusion.

I am firmly convinced if you want to make fusion go you are going to have to have the people who are involved be those who really believe in fusion.

I would take some objection to what Dr. Landis said, that industry is in it simply to make a profit.

Industry will be in it to make a profit, and should be, downstream, when it can assess whether or not this is going to be a viable industry and a viable sort of endeavor to get involved in.

But I would submit that, for the first FED, industry doesn't want to lose money as a result of the proposition, but it is not a product line that is going to be developed initially or immediately. In this very high risk business—industry must endeavor to find out what has to be developed, what are the risks, which are the time scales, what are the realities, and then I can see an industry springing from that, one in which various companies, if they choose to stay in the business, will be bringing out their own versions.

But I would say that through the nineties, industry will not be making a profit other than whatever it is normally allowed in fees so that on their own they can plow back their moneys into building the future "better mousetraps" which they can indeed then sell to the utilities.

Mr. REICHLE. Shouldn't we also keep in mind that we are not at a dead stop in terms of going to a FED?

There is the Fusion Engineering Design Center at Oak Ridge. It is coming up with a preconceptual design. Contributions to that design have come from many different organizations. In general, there is recognition that a tokamak is the front runner.

In the longer run, the burden of proof is on other designs. If another magnetic fusion device comes along that is better than a tokamak, good for it.

Mr. SPENCER. I have a question for Dr. Agnew.

Having been both at Los Alamos and now with a major company, one of the questions which is in my mind is, at what time or at what stage of the development of a new technology—and having been in the aerospace business for 16 years, I understand that

pretty well—what stage is proper to really move a technology completely into the industrial sector?

Frankly, I have some concerns as to whether we are taking what is almost scientific achievement and saying it is now ready to go to the industrial sector instantaneously.

I would like to have your views on that.

Dr. AGNEW. I think I share your concerns because I think in this technology and in other technologies that I can look back on, the desire to put it into the private sector was so strong that it happened too soon.

And then people get into problems. Most industrial concerns do not have a scientific laboratory backup that can compare with what exists in the National Laboratories.

And that is why I feel in this program we need to keep the National Laboratories tied in, because there will be problems, problems in materials in particular.

There could even be problems in understanding some of the basic physics which will arise, and I think it is only the National Laboratories and the very strong theoretical groups that exist—or by “National Laboratories” perhaps I should say those programs which are being funded by the Federal Government, where you can bring in resources on a very quick basis in order to solve the problems.

My own experience in this sort of industry-lab cooperation is in the defense and in the nuclear weapons business, where you have private contractors who are actually doing the construction and manufacturing, but the National Laboratories—Livermore, Sandia, Los Alamos—are backing them up. And when they run into a problem, there is a very easy way of bringing in that technical scientific resource. I don't think it will ever be possible or wise to turn it completely over to industry without having that technical reserve backup available to solve problems, which arise continuously. I think the same thing will be true in fusion, and I think it will go on for many decades.

So I don't think the object should be to say, “Oh, boy, industry, the Government is going to put together this consortium, or whatever you want to call it, we are going to build the first one, and then we are going to say, ‘There it is, there it is, industry,’ and then walk away from it.” I think that would be completely fallacious.

Mr. REICHLE. This goes back to your basic presentation in which you urge strong industrial leadership but at the same time a recognition on a continuing basis of the contribution that the National Laboratories must make.

Dr. AGNEW. That's right. I think the main role of the industrial leadership will be in the marketing, making it available, essentially, worldwide.

Mr. McCORMACK. But before that, really, isn't it providing the engineering talent that doesn't exist in the plasma physics laboratories in the community today?

Dr. AGNEW. That's true; but you will find that there is also some degree of engineering capabilities in the National Labs, in the universities, and the universities teach it.

Dr. LANDIS. By “marketing” do you mean directing it into something that will be fruitful commercially?

Dr. AGNEW. That's right. And pointing out, you know, everything, from the financing to doing the analysis of why a utility should dump whatever they have in hand and start to plan for this in their next generating plants, all of that.

Dr. LANDIS. I certainly agree with you, Harold, that we have got to utilize the talents of the national laboratories and the universities, and so on, that have been working. And that is one of the reasons why I think it is an extremely difficult job for an industrial contractor.

You say you take exception, at least some mild exception, to my mentioning a profit. But most companies do have to show that they are earning a profit, and it seems to me that if you make one of the criteria of selection of the CFE how long can the contractor go without earning a profit, you may be skewing this thing toward very wealthy companies instead of those who will do the very best job of coordinating the massive array of talent and experience that has to be coordinated. I mean that is my worry.

Dr. AGNEW. By "profit," I mean they shouldn't lose money. But they may not make the money that some industries expect on return of their capital.

Dr. LANDIS. You mentioned industrial—I mean defense contractors, of course, they make a profit, and they have learned how to do this job well, the thing that I am worried about.

Mr. REICHLE. Isn't it likely, though, that what we are talking about, in any event, is a cost-plus-a-fee kind of contract which industry and government are familiar with?

This is how the aerospace program is developed. This is how the fission reactor program developed. This is how the defense program developed. So, we are not talking about industrial profit in the normal sense. We are talking about industry management of an activity on a cost-plus-fee basis.

Mr. SHERMAN. I agree with Dr. Agnew.

The industry certainly would not be looking to lose money on this kind of a project.

However, when you talk about profit, the kind of people that industry would be assigning to this sort of a job really get to be the cream of the crop, the kind of people on whom they normally earn their biggest return, particularly true of a service organization and I think, probably, of a manufacturing organization also.

Now, in that sense, you might say there is no profit in it, because here are these people on a very-small-return job, assigning their top resources, top human resources, to the effort.

Mr. REICHLE. That is a very important point.

Mr. MAXWELL. I don't think any of the four of us want to duck forever the question you originally raised, Dr. Landis, about how do you insure good performance from this industrial concern or consortium.

I think that there is always a customer, and the customer, you know, if it were organized today is the Department of Energy, with very strong oversight available to and afforded by the Congress, I think Mr. Sherman gave you three very important milestones over the period of the next 9 or 10 years, and I think that all of us, if we sat down, could come up with several or a dozen important milestones for every year which occurs between now and then.

I would say that the least praiseworthy effort of an organization like the CFE is to spend x amount of dollars per year. It ought to commit up front what it is going to accomplish that year, and I suspect that there are ways for its customer and the Congress to make these very visible: Do they do it, or don't they?

Dr. LANDIS. Thank you. You are getting to the point that I am glad we are addressing, and that is: Isn't it most important now to define exactly what we want the CFE to do and to do that very quickly, with knowledgeable people, so that you don't get into the position of setting up a CFE and then finding out that you are developing the goals for the CFE as it goes along, and if the CFE is run by a strong management, as you have all recommended, that manager will influence the goals vitally.

And I would like to see all of these goals set forth very clearly before we launch such a tremendous operation.

Mr. MEAD. I think that is one of the key recommendations in this AIF report, that just that be one of the next steps, which is to put together a joint industry-governmental task force to try to define those objectives, responsibilities, and so on.

Dr. LANDIS. I gather that, from what Sid said—I just wanted to emphasize that a little bit.

Mr. REICHLE. Actually, there have been many submissions as to potential functions of the CFE. Bob Sherman mentioned some, the AIF panel has presented others.

I think one of the activities that our panel might address tonight when we have dinner and discuss today's meeting is what specifically we might recommend to Congresswoman Bouquard as some specific functions that we think are the proper functions for this kind of an organization to undertake.

Are there other comments from panel members?

Mr. BLATTNER. Since all of these gentlemen represent industry, what means do you see for forming a separate corporate entity or even bidding against others in this CFE role? What kind of problems do you see in forming some kind of a bid team, which is done frequently in DOD but hasn't been done in fusion too frequently?

Mr. SHERMAN. It sounds like a standard business problem, to me. I don't view that as unusual.

Mr. MEAD. We face it every day.

Dr. FURTH. It seems to me that's a very important aspect of this whole CFE question. The object is to involve industry with a capital "I". If it is gone at too narrowly, it will involve an industry, namely the industry that gets the CFE, and as for the others, they will, of course, be brought in under various subcontracts, but they are brought in under various subcontracts now.

So it seems to me that some thought should be given how to set up this mechanism in such a way that it will bring in industry a little bit broadly rather than just one.

Do you have any comments?

Mr. MEAD. Conceivably, the ground rules for selecting the CFE could establish some minimum criteria that encompasses these various aspects of industry.

Dr. FURTH. Do you have any good ideas?

Mr. MEAD. As a general rule, it certainly ought to include the power industry somewhere, it ought to include the A/E companies

perhaps typical aerospace companies that are currently involved in it, other major—I can see putting together a consortium of companies under a prime that would cover all of the important current contributors.

Mr. SHERMAN. An alternative method is to form a joint venture company which is frequently done in large engineering construction projects where a joint venture company will have a number of coventurers that will bring to bear all of the skills necessary to run the job, and they will be stockholding participants in the joint venture.

Dr. FURTH. Joint venture sounds like a good name for it.

Mr. MAXWELL. I think it is important to remember in this day of the Clinch River breeder programs and others like that, we are talking about 20 years as a minimum for what you are looking forward to the CFE doing. Probably the most important thing one could do up front is not to make it so rigid that you cannot alter it as we get smarter.

Mr. McCORMACK. I think it is important to remember that the reason CFE was conceived was that it was considered to be the most important mechanism for taking the first step in the engineering phase of the fusion program. The second step was getting the FED on line and then ultimately the fusion demonstration plant.

I would be reluctant to see any philosophic overlay on top of that. I would not go for diversification for diversification's sake, for instance.

I think our goal is to get FED on the line and the mechanism is to use CFE to do it because it appears that there is not any existing mechanism good enough to do it and after that you put what limitations or requirements that would be appropriate on it; but remember the goal at all times. I think that is the important point.

Mr. SPENCER. Mike, I agree with you, but I think my concern is that as we found in the aerospace business and the light water reactor business, that as we got into a very clear objective of where we were going, we then began finding out how complex the problem really was.

Mr. McCORMACK. Oh, yes.

Mr. SPENCER. So you need the broad-based capability, in my view.

Mr. McCORMACK. I very much agree with you that undoubtedly they need that; but any successful bidder is going to be a bidding team and they are going to have A and E experience and advanced technology experience and nuclear engineering experience, among other things, on the team. I think that is almost certain.

I get gun shy any time anybody wants to try to go into anything that might show up later in our committee reports.

Dr. AGNEW. I would urge you also to make clear what the relationship will be between the CFE and I guess I would say broadly the DOE, that if not handled properly could be a nightmare for both parties.

Mr. REICHLE. Do you have any thoughts as to what that relationship should be?

Dr. AGNEW. I guess once the CFE structure, let me call it that, when the person in charge of that is decided upon, then I would hope that the DOE would be enlightened to the extent that they

would leave CFE alone for the longest possible time and not have, as I have seen in some advanced programs, such idiotic things as weekly progress reports.

Mr. McCORMACK. Then you need two teams.

Mr. MAXWELL. This does highlight in part that area in which I seem to depart from the mainstream here.

Most of us are very familiar with the Washington scene and probably it is unfortunate that the Act and concept of the CFE have arrived nearly simultaneously with a very fluid situation in the DOE; but by now we should be pragmatic enough to recognize that I do not think the CFE is going to go very far unless the DOE or its successor with its responsibilities is a participant in its definition and is comfortable with what has evolved, and that will take time.

Mr. REICHLE. Dr. Agnew mentioned at the beginning his feeling that what we really need is a commitment, a strong national commitment. I think everyone senses that.

Do any of the panel members have any thoughts on how you go about getting a national commitment that becomes a major function of DOE, or other organization?

Mr. MAXWELL. We sit here staring at the exhibits on the wall. One can only conclude that it is probably more difficult to get a national commitment if we are trying to entrust what you want CFE to do to an industry group, you know, than a NASA with an Apollo program. It is more difficult.

Dr. LANDIS. I would agree with that completely. I think it is a horrendously difficult job, not only technologically, but also institutionally.

Mr. MAXWELL. I seem to be talking too much; but we do share, we have the blessing of being one of the few energy technologies that is not ready for commercialization.

Mr. REICHLE. We hope fusion has greater potential than some of them.

Perhaps one of the ways of getting a commitment would be to have a clear set of steps for going ahead and a well-defined charter for the Center for Fusion Engineering, with specific functions which the industry in general can agree upon so that the people in Congress and in the administration can see as a mechanism to carry out the program.

Dr. AGNEW. As we look at the picture, clearly the success of that Apollo program was because of the executive leadership saying that that was going to happen in a decade.

Mr. MAXWELL. That's right.

Dr. AGNEW. If you can get the same sort of statement from the administration, I have no question that the same thing can happen; but it takes that sort of commitment so that the various, what I prefer to call, valves in the system can get out of the way and let the pumps operate.

Mr. REICHLE. Does the panel feel that the industry as a whole would support a recommendation to the President saying, "We recommend, Mr. President, that you get behind the next move in fusion the way President Kennedy did on space."

Mr. SHERMAN. There is a little bit of a problem there. You know, in the space program we were going to beat the Russians to the

moon, so we wrapped the flag around the whole thing. It is kind of hard to wrap a flag around something that has the name "Tokamak."

Mr. REICHLE. Well, maybe if the Japanese are about to plunge forward with a \$3 billion program, this should be an element of competitiveness internationally.

Mr. CAIRNS. We have questioned various things, whether the FED should be a Tokamak, whether it should be something else, whether we need the CFE before or after FED. If we make the one assumption that the FED is somewhat of the form as it is now envisaged, Tokamak, and we go along with the Act and set the target for that to be 1990, that is awfully optimistic, do we then, do you gentlemen then consider that setting out the CFE first will accelerate the realization of that FED?

Dr. AGNEW. I would say that it would, but I can see another role for the CFE; that is, to plan the development so that we do not end up the way say the British ended up at the end of World War II; namely, they won, but there was no plan as to what the hell they were going to do from there on out, the way we ended up with that spectacular space program, which is around our walls.

We really got to the moon a little too early. I think we might recall the nuclear rocket program, a fantastic program. It was done on schedule within costs, but the world was not ready for it; so I can see the CFE doing more than just bringing in the one device and saying, "There you are."

I think there is a long road to see where it fits into the total, let me call it energy economy, of the United States and perhaps the world. I think there is a very important planning function, because if you bring it in too soon, and there are other commitments by the utilities so that nothing happens to it and it languishes, then your technical teams, your expertise, and all the rest will atrophy and it will be very hard to get the esprit de corps going again; so there is another reason for that program of the CFE, other than just getting the thing done in the quickest time, which I think it can do.

Mr. REICHLE. I know others will want to stand back and make their own assessment, but I thought Bob Sherman gave a good picture of fusion as an important option for central station electric power. Looking ahead between now and the year 2000, all we have is coal and present generation nuclear. After that, we have the breeder, hopefully, but we ought to have another option. The time may be closer than we think when there will really be a need. When we back up from that time of need, we find we must get started promptly.

Dr. FOWLER. One question that is going through my mind that I would like to raise with the panel touches on a number of the issues today; but I think it can be summed up this way. Is there anything you have noticed about this program that means that looking at models in the past is the wrong way to look. Is something unique about this fusion effort, that will call for a unique procedure in order to bring into being fusion energy? Can we be sure that the old models are not going to work? To bridge this gap between the long-term scientific development or long-term engineering development, and ultimate implementation we need a com-

pletely original idea. Is there something unique about fusion that is not to be found in your or our past?

Mr. REICHEL. I think the uniqueness is the time frame. The ultimate target we are trying to hit is further out there. In the space program, it was only 10 years.

Dr. LANDIS. Ken, do you mean unique technical characteristics?

Dr. FOWLER. It is a combination. It is the technical characteristics that will also dictate the implementation characteristics. Sometimes the further away something is, you know, in a certain sense the more philosophically you treat it, if I may say so and, frankly, I think that is how fusion got this far. It was not taken as something that if it does not pay off in 5 years, it is not going to work; but it was taken as the high risk, but big return goal that kept people working for already a uniquely long time.

Mr. MEAD. Well, I think one thing a little unique is that the implementation of this ultimately has got to be done by the private sector, as opposed to some of the other major programs which we have been talking about here, which wound up being Government programs and are still Government programs.

Dr. FOWLER. Why is that?

Mr. MEAD. Well, it puts a different flavor on who should be getting involved. In terms of getting industry involved now, rather than waiting until it is, say, proven.

Dr. FOWLER. That is taken for granted that that involvement is the key now.

Dr. AGNEW. I hate to muddy the water, but I can see where that might not happen. If for some reason you go toward breeders, then I think the breeders can stay in the Government sector.

Dr. FOWLER. Harold, we can't hear you.

Dr. AGNEW. I am saying that if you make a turn going down the road and you turn toward breeders, then the Government will play a heavy role—

Dr. FOWLER. Regulatory role.

Dr. AGNEW. In product and regulatory to the point let us say that the only individuals who could sell the product would be the Government, either because of licensing or they will take it.

You know, the analogy of this whole thing in a way is the Manhattan project. You could say that the Army Manhattan project was the CFE. They got industry and the universities and they went hell bent for leather to do something that they were not even sure they could do; but somehow the basic physics was there. They needed it. There were some false starts and false turns, but then industry, the universities, teamed together and brought it in. Now, there was an urgent time frame and it was all done. It was accomplished.

Dr. LANDIS. Creating that same atmosphere in the situation today is what I am worried about.

Dr. AGNEW. It is hard.

Dr. FOWLER. John, some of what is on my mind is that I believe that one should not hold back and hold back from bringing industrial involvement into this program.

On the other hand, I am concerned that in industrial involvement, that there was not a question, at least, whether there is something unique in investment here that will not come in and

hurry the birth of the baby in a way that will make problems for the program.

Is there not something unique that industry will have to learn melding into this program as we will have to learn in giving it up?

Mr. MAXWELL. I do not identify too carefully the uniqueness of fusion per se. I think a possible uniqueness is the current time we live in. We have lost our innocence. Nuclear power is not so cheap that you can give it away. I think that there have been few words here today about the sociopolitical implications of a fusion-electric economy. Those things are ahead of us and all I can say is that the framework in which we do our planning for the next 10 or 20 years is certainly with a lot more blinders off our eyes today than it would have been 10 or 15 years ago.

Mr. REICHLE. There may be some relationship between the stage we are at now in fusion and the early fission reactor development program. In the early days of the fission reactor program, the Argonne National Laboratory said, "This first demonstration plant as something that Argonne will design and build and operate," that was the EBWR, the experimental breeder reactor. It was designed and built at Argonne, but it contributed little. It was not until General Electric in the case of the boiling water reactor program got in and provided their industrial management and engineering that the program moved ahead.

Of course, the funding situation was different. G.E. did a good part of their learning on private financing. But, whether it is Government financing as in the nuclear Navy program, or private financing as the industry did in the case of the power reactor program, the transition was made at a fairly early stage to industrial management and engineering development.

Do we have a similar situation in fusion?

Mr. SPENCER. Let me comment in the context of the utility industry, and that is that the utility industry is now trying to bale out a lot of those decisions that were made by the private sector without having adequately looked at the operating implications on light water reactors. Having been in the light water reaction design business, I know a lot more now than when we first started; but I do think we have got to be very cautious of not assuming that we know how to design these systems prematurely. I am very concerned about that.

Mr. McCORMACK. I think it is very important to remember that FED is just simply the first machine in which we are going to have a combined and presumably controlled fusion reaction. It is nothing more. If we get engineering experience on how to turn that machine off and, and keep it running and get materials testing experience, and this sort of thing, it is going to be a magnificent accomplishment.

Out beyond that is the first consideration of real significant industrial involvement and that is in the 1990's. If we make FED run and then say, now how do we make a demo plant and what basic approach do we use and how we are going to do it, that is when industry looks seriously at the thing, at the industrial application, what would be involved, and so on.

It is important to remember that the FED is nothing more than making the same goal for the first time.

Dr. FOWLER. Well, maybe the essence of that comment might be, what do these gentlemen see then as the role of industry between now and 1990?

Mr. SHERMAN. Well, I would say it is first, to run the program, as I think a great many of us here agree and to bring in and manage the industrial participation which will be the development of this Machine to the point where you can turn it on and turn it off, hopefully. It is a multitude of engineering problems and decisions and proof testing which is the standard activity of many industrial organizations.

Dr. FOWLER. What I am getting at is that I think we have discussed this in very different roles. One, industry may be needed to get it to work. The people involved do not have that expertise.

The other is working on this mission by industry may be needed to make industry ready for the 1990's.

Do you think both roles are valid, neither is valid, or which?

Dr. AGNEW. I think both are valid, but I do have a concern, again using an analogy; when you build a machine in the context of Mike's statement, there it is. Now industry will replicate it. It would be tragic if it turned out to be the wrong machine. That has happened, I might say, coming from a prejudiced viewpoint, but I can quote, there was a statement by Frank Press, now president of the National Academy, he was the President's science advisor some years ago, a very interesting quotation in a memo he sent to Mr. McIntyre, who was head of the OMB. It says: "In retrospect it would appear to me that we made the wrong choice in our nuclear power system."

The industry will be starting from a base, just having available what it has, building on that investment of several billion dollars it just cannot drop that and come up with another \$1 billion on its own to run off in a different direction. I do not know how you cope with this in order to make a decision very early.

Mr. McCORMACK. I would suggest that FED is much closer to CD-1 than it is to Shippingport.

I think it is completely possible that we might make FED as a presently conceived TOKAMAK and wind up, in general, with it being an Elmo Bumpy Torus or a mirror machine or something that we have not thought of yet.

I am not sure that is a loss at all. I think we may necessarily have to go through that.

Furthermore, it is not industrial money that is going to do it. It is Federal money. That is why we have it set up that way in the bill.

Dr. AGNEW. That is why I think it is important that the Federal Government have the commitment to bring into being what is the best thing to bring into being, simply because they bring in one thing and it subsequently turns out it should have been something else, they must not just wash their hands of it and say, "Well, fusion is fusion is fusion."

Mr. McCORMACK. That is why we put both steps in the bill, the FED and the demo. The record will show that we said that the FED will be the simplest possible machine—I am paraphrasing this—that will work, and the demo will be something beyond that that will produce power. We did not say they will be the same

design and be the same concept, but they will both be a fusion machine.

Dr. LANDIS. Getting back to the question of how the CFE should be established and organized, it sounds to me that tying together several of the comments that have been made, both by the panelists and by the committee, that we are inclined a little bit toward what Bob Sherman mentioned earlier, a joint venture. If you want to tie in, as Harold mentioned, all the elements of the society or the economy here, the industrial complex that we are talking about, it might be best to have the prime contractor be a composite of those elements—the university representative, the national laboratory representative, a manufacturing representative and an engineering representative, which somebody mentioned earlier; but it sounds to me as though that is the way this whole conversation today is leaning.

Mr. REICHLE. It certainly is one option.

Are there any further comments or questions on the part of the panel? If not, I would like to thank the four members of the panel for their contributions. We appreciate it very much.

Our third panel will be comprised of Dr. Don Kummer, Manager of Fusion Energy for McDonnell Douglas; Dr. Pete Staudhammer, Laboratory Manager, Nuclear Energy, for TRW; Dr. Don Anthony, Manager of Fusion Energy Systems for General Electric; and Mr. Martin Scholl, Associate Technical Director, Energy and Resources Division of MITRE.

The first to speak will be Dr. Don Kummer.

STATEMENTS OF DR. DONALD L. KUMMER, MANAGER, FUSION ENERGY, McDONNELL DOUGLAS CO.; DR. PETER STAUDHAMMER, LABORATORY MANAGER, NUCLEAR ENERGY, TRW CO.; MARTIN SCHOLL, ASSOCIATE TECHNICAL DIRECTOR, ENERGY AND RESOURCES DIVISION, MITRE CORP./METREK DIVISION; AND DR. DON ANTHONY, MANAGER, FUSION ENERGY SYSTEMS, GENERAL ELECTRIC CO.

STATEMENT OF DR. DONALD L. KUMMER

Dr. KUMMER. Mr. Chairman, members of the Fusion Advisory Panel, the opportunity to present some thoughts on the Center for Fusion Engineering to the panel is most welcome.

McDonnell Douglas, my firm, is primarily in the aerospace business and has been involved in fusion for over 6 years. Our largest single fusion program is the design and construction of the Elmo Bumpy Torus proof-of-principle device.

I will first address the basic factors involved in advancing fusion engineering which center around a Fusion Engineering Device. Then I will discuss the method of implementing it through a Center for Fusion Engineering and suggest basic premises on which the Center should be established. First, a brief assessment of magnetic fusion status:

We believe fusion is ready for a major engineering thrust of which FED is the centerpiece. In making this assessment we have considered the physics, engineering, and manufacturing aspects of the fusion program. The physics community has concluded that the science is at hand to proceed with large experiments such as the

FED. Based on our experience in some of the most challenging engineering efforts over the past 30 years, we have concluded that the engineering can be accomplished.

In manufacturing, the fusion community is reducing to practice the fabrication of large, complex, and high-precise components. For example, large superconducting magnets are being fabricated successfully, neutral beam lines with their precise ion sources are operating, and gigahertz frequency microwave power tubes are being built reproducibly.

Studies of fusion devices from the subsystem level through complete commercial powerplants have built our confidence that in the future a fusion powerplant can be designed to meet the requirements of an electric utility. At this time it is necessary to obtain the needed information by moving into the integrated engineering design and operation of the combined subsystems. This is the purpose of the Fusion Engineering Device. It is critical for the advancement of fusion energy to its commercial application.

Next, a few comments about the Fusion Engineering Device. An issue requiring further examination is the size of the FED. The development of fusion power is evolving through a series of large experimental devices having progressively greater capability. The FED in turn is followed by a power-producing demonstration plant, which, in turn, will be followed by a powerplant. We firmly believe that if the FED is to be of maximum benefit to the total program, its optimum size and performance should be determined before budgeting constraints are imposed. To proceed otherwise may prove costly, both in time and in money. An FED that is too narrowly conceived because of funding restrictions may mean that additional large devices would be needed. These additional steps would delay the development of full-scale operating plants and add to the total cost.

Finally, some specific comments on the Center for Fusion Engineering: Discussion of a CFE has been brisk since it was incorporated into the Magnetic Fusion Energy Engineering Act of 1980. A commitment to build an FED is necessary before proceeding with the establishment of a CFE. Without this commitment, the need for the new center is insufficient. When the FED project is assured, the center can be a good implementing organization.

For the Center to perform its mission successfully requires the full support of Congress and the Department of Energy and the enthusiastic cooperation of industry, the national laboratories, and universities. This can occur only if the CFE roles are clearly delineated from the beginning. When the bounding conditions for the CFE are not fixed, it is inevitable that the laboratories, universities, or industry will find that their traditional roles are being infringed and they will protest. There are historic examples where Congress has been obliged to investigate and require reorganization or redirection of an overly ambitious center. To insure support and cooperation of all groups concerned with fusion R. & D., we recommend the following features for the CFE:

First, its function should be planning, programmatic, and technical administration in support of the Office of Fusion Energy. A high level of experience will be required of CFE personnel. Experienced project managers, technical specialists, procurement experts,

and contract administrators are needed to successfully identify the needs and manage the placement and performance of contracted work.

Second, its charter must exclude CFE from doing laboratory or hardware work. To obtain the full cooperation of the fusion community, CFE should not compete with the national laboratories, universities, or industry. These groups need to be utilized and strengthened for future roles. CFE work, including analysis, testing, and design, should be contracted by CFE to appropriate organizations. Conflict of interest must be scrupulously avoided.

Third, it should report to the Office of Fusion Energy, that is, OFE. OFE can both direct CFE and represent it in the budget process better than groups above or below it. This single line of authority will focus the fusion program within DOE.

Fourth, it should operate in the "industrial style." This means having the ability to make procurements expeditiously, being responsible for cost and schedule performance, and being responsive to the customer's direction—in this case, OFE's direction.

Fifth, it should be a nonprofit entity. Consistent with the role we have been describing, profit is not really required.

Lastly, it should be a small group with a modest manpower ceiling. Organizations of this type have successfully managed large projects with less than 50 professional persons. A manpower ceiling will put a premium on experienced employees, limit the ability for micromanagement, and inhibit the proclivity to expand the charter.

In arriving at these features that I have mentioned, we reviewed our experience in similar programs that were performed for many customers having different forms of management organizations. The military services in the Department of Defense have systems development commands that manage the industrial and laboratory participants in each project. There is no equivalent in the Department of Energy, and the CFE would partially perform this role.

The Army used Bell Labs and Western Electric to manage missile defense projects for over two decades somewhat like the CFE. McDonnell Douglas was the missile contractor for Bell Labs and Western Electric. When Bell terminated its participation, McDonnell Douglas won the role competitively, so we gained experience both as a program subcontractor and currently as the program manager. We have performed missile and space programs for the Air Force where the Aerospace Corporation serves as a type of CFE organization.

Another type of experience comes from our work for NASA. In moving from the National Advisory Committee for Aeronautics into the space mission, NASA established four new centers. These centers manage the work of industry, other NASA research centers, and many other Government and private groups. We have been involved in programs coming out of these NASA centers for more than 20 years. And I can't help but add that we see in this room many of our programs surrounding us here today—Mercury, Gemini, the Skylab, and part of the Apollo program.

In conclusion, the guidelines recommended for CFE come from experience in working with Government-directed management organizations for many years on numerous and varied programs. In-

corporating these guidelines, we believe, will maximize the cooperation and utilization of the fusion community, which is the key to success.

Thank you, Mr. Chairman, for the opportunity to present these recommendations to the panel on behalf of McDonnell Douglas.

[The prepared statement of Dr. Donald L. Kummer follows:]

Remarks of Donald L. Kummer
MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
St. Louis, Missouri

Before The
FUSION ADVISORY PANEL
June 29, 1981

Mr. Chairman, members of the Fusion Advisory Panel, the opportunity to present some thoughts on the Center for Fusion Engineering (CFE) to the Panel is most welcome. I will first address the basic factors involved in advancing fusion engineering which center around a Fusion Engineering Device (FED). Then I will discuss the method of implementing it through a Center for Fusion Engineering and suggest basic premises on which the Center should be established.

Assessing the Status of Magnetic Fusion - We believe fusion is ready for a major engineering thrust of which FED is the centerpiece. In making this assessment we have considered the physics, engineering, and manufacturing aspects of the fusion program. The physics community has concluded that the science is in hand to proceed with large experiments such as the FED. Based on our experience in some of the most challenging engineering efforts over the past 30 years, we have concluded that the engineering can be accomplished. In manufacturing, the fusion community is reducing to practice the fabrication of large, complex, and high-precision components. For example, large superconducting magnets are being fabricated successfully, neutral beam lines with their precise ion sources are operating, and gigahertz frequency microwave power tubes are being built reproducibly.

Studies of fusion devices from the subsystem level through complete commercial power plants have built our confidence that in the future a fusion power plant can be designed to meet the requirements of an electric utility. At this time, it is necessary to obtain the needed information by moving into the integrated engineering design and operation of the combined subsystems. This is the purpose of a Fusion Engineering Device. It is critical for the advancement of fusion energy to its commercial application.

The Fusion Engineering Device (FED) - An issue requiring further examination is the size of the FED. The development of fusion power is evolving through a series of large experimental devices having progressively greater capability. The FED is planned to be followed by a power-producing demonstration plant, which, in turn, will be followed by a power plant. We firmly believe that if the FED is to be of maximum benefit to the total program, its optimum size and performance should be determined before budgeting constraints are imposed. To proceed otherwise may prove costly--both in time and in money. An FED that is too narrowly conceived because of funding restrictions may mean that additional large devices would be needed. These additional steps would delay the development of full-scale operating plants, and add to the total costs.

The Center For Fusion Engineering (CFE) - Discussion of a CFE has been brisk since it was incorporated in the Magnetic Fusion Energy Bill of 1980. A commitment to build an FED is necessary before proceeding with the establishment of a CFE. Without this commitment, the need for the new Center is insufficient. When the FED Project is assured, the Center can be a good implementing organization.

For the Center to perform its mission successfully requires the full support of Congress and the Department of Energy and the enthusiastic cooperation of industry, the national laboratories, and universities. This can occur only if the CFE roles are clearly delineated from the beginning. When the bounding conditions for CFE are not fixed, it is inevitable that the laboratories, universities, or industry will find that their traditional roles are being infringed and they will protest. There are historic examples where Congress has been obliged to investigate and require reorganization or redirection of an overly ambitious Center. To ensure support and cooperation of all the groups concerned with fusion R&D, we recommend the following features for the CFE:

- o Its function should be planning, programmatic, and technical administration in support of the Office of Fusion Energy. A high level of experience will be required of CFE personnel. Experienced project managers, technical specialists, procurement experts, and contract administrators are needed to successfully identify the needs and manage the placement and performance of the contracted work.
- o Its charter must exclude CFE from doing laboratory or hardware work. To obtain the full cooperation of the fusion community, CFE should not compete with the national laboratories, universities, or industry. These groups need to be utilized and strengthened for future roles. CFE work, including analysis, testing, and design, should be contracted by CFE to appropriate organizations. Conflict of interest must be scrupulously avoided.

- o It should report to the Office of Fusion Energy (OFE). OFE can both direct CFE and represent it in the budget process better than groups above or below OFE. This single line of authority will focus the fusion program within DOE.
- o It should operate in the "industrial style." This means having the ability to make procurements expeditiously, being responsible for cost and schedule performance, and being responsive to the customer's (OFE's) direction.
- o It should be a not-for-profit entity. Consistent with the CFE role described, profit is not required.
- o It should be a small group with a modest manpower ceiling. Organizations of this type have successfully managed large projects with less than 50 professional persons. A manpower ceiling will put a premium on experienced employees, limit the ability for micro-management, and inhibit the proclivity to expand the charter.

In arriving at the above features for the CFE, we reviewed our experience in similar programs that were performed for many customers having differing forms of management organizations. The military services in the Department of Defense have System Development Commands that manage the industrial and laboratory participants in each project. There is no equivalent in the Department of Energy, and the CFE would partially perform this role. The Army used Bell Labs/Western Electric to manage missile defense projects for over two decades in a role somewhat like the CFE. McDonnell Douglas was the missile contractor for Bell Labs/Western Electric. When Bell terminated their participation, McDonnell Douglas won the role competitively, so we gained experience both as a program

subcontractor and currently as the Program Manager. We have performed missile and space programs for the Air Force where the Aerospace Corporation serves as a type of CFE organization. Another type of experience comes from our work for NASA. In moving from the National Advisory Committee for Aeronautics (NACA) role into the space missions, NASA established four new Centers. These Centers manage the work of industry, other NASA Research Centers, and many other government and private groups. We have been involved with programs coming out of these Centers for more than 20 years.

Conclusion - The guidelines recommended for CFE come from experience in working with government-directed management organizations for many years on numerous and varied programs. Incorporating these guidelines, we believe, will maximize the cooperation and utilization of the fusion community which is the key to success.

Thank you for the opportunity to present these recommendations to the Panel on behalf of the McDonnell Douglas Astronautics Company.

Mr. REICHLER. Thank you, Don.

The next speaker will be Dr. Peter Staudhammer.

STATEMENT OF DR. PETER STAUDHAMMER

Dr. STAUDHAMMER. Mr. Chairman, members of the panel, I am honored to have the opportunity to appear before you to talk to you about issues surrounding the management of the national fusion engineering program and, in particular, the Center for Fusion Engineering.

I believe that convening of this advisory panel at this time is especially significant since the future of the magnetic fusion program may well be in jeopardy today. In spite of the many significant successes of the magnetic fusion program and in spite of the passage of the Magnetic Fusion Energy Engineering Act of 1980, the proper continuation of the program is in jeopardy, first, because of lack of commitment in funding, and, second and perhaps even more importantly, lack of commitment to go on to the engineering phase.

It may well be that the larger commitments in fusion engineering, such as the FED, cannot be made at the present time due to tight budgetary pressures. However, there is all the more reason to put the management structures in place that can scope and plan a comprehensive fusion engineering development program. I urge this panel to recommend that these appropriate structures be put into place as soon as practicable.

At this point let me address myself to the management structure for the engineering program. The basic concept of CFE was proposed by the fusion review panel of ERAB and is embodied also in the Magnetic Fusion Energy Engineering Act of 1980. I believe this concept is a very good one because it fills a very definite need.

The current fusion research program is very well managed by DOE in a decentralized fashion. However, the fusion program is now turning from research, which is characterized by a step-by-step evolution—one following from the previous one—to an engineering development, which is characterized by definite goals and highly complex, but nevertheless highly integrated, programs. Such a complex but highly integrated program requires a strong central management organization that is capable both to manage and to technically understand and direct the program.

I would like to remark here that we are not talking here about the FED alone, we are talking about the FED and a broad engineering development program. The problem is not to just manage one single project. The problem that confronts us is to manage a whole set of programs. It is a programmatic integration of many projects we are looking at, and that is why one cannot just go to a single prime contractor and have him manage just one project. We are facing many such projects, all together.

Creating a new national center, which is normally referred to as a CFE, that can concentrate the right kind of talent from all across the country is an ideal way of accomplishing that end.

Building an organization which offers both the required technical talent and the strong management orientation is best accomplished in an industrial environment. Industry has traditionally played such a role in major programs in the United States and has a very

good track record in its ability to manage complex, high technology programs. Industry can offer incentives to attract the highly qualified management staffs and is able to staff and de-staff in accordance with program requirements. In turn, the Government retains control over the industry through profit incentives and the prospect of eventual commercialization.

Let me deviate at this point from my text and remark that I see the fusion program as having three major phases: The research phase, the engineering development phase, and the commercialization phase.

The research phase very clearly is carried by the national laboratories, and is being done very well. By the same token, the commercialization phase on the other end of the spectrum has to be carried by industry. The question, I believe, you are really confronting today is whether the national laboratories should do the engineering development as essentially the final part of their responsibility in fusion, or whether industry ought to do that development as the first step in a progression that goes on to commercialization.

I would say that you definitely want to get industry involved, because engineering development is the first step toward the long-range goal of fusion. However, I would like to caution you not to make the kind of distinction between national labs and industry as I have just implied, and as many of us here have implied. I think this has to be a complete partnership between the national labs and industry. The national labs ought to, and have to, continue doing the research work they are currently doing. This will probably even continue beyond the time the first demonstration system is built. There will be many things the national laboratories will have to still contribute in order to make fusion a better and more acceptable kind of energy alternative.

So it is a partnership, I believe, between industry and the national laboratories that we are looking for, with industry taking responsibility for the engineering development and for commercialization beyond that.

Let me give you an example of a highly complex technology program which has many parallels with fusion today, and that is the development of ballistic missiles that I personally was involved in. Just as in fusion today, in the late 1950's, there was a strong consensus that the ballistic missile should be developed, but much of the technology and much of the physics in fact was not available at the time. As in fusion today, several parallel paths of research and development were pursued in critical areas. Some work was done in the military arsenals, and some in the national laboratories, though most of the development work was done by industrial contractors. The responsibility for technical coordination of the large number of these interrelated program elements was given to an industrial firm, Space Technology Laboratories, currently part of TRW. This company then acted as the systems engineer and technical director for the ballistic missile development program.

The main task of the systems engineer and technical director was to provide overall plans and system specifications to define a set of subsystems which could be developed by separate contractors, to set subsystem performance requirements and interfaces, and to technically overview and to direct the individual contractors. Inter-

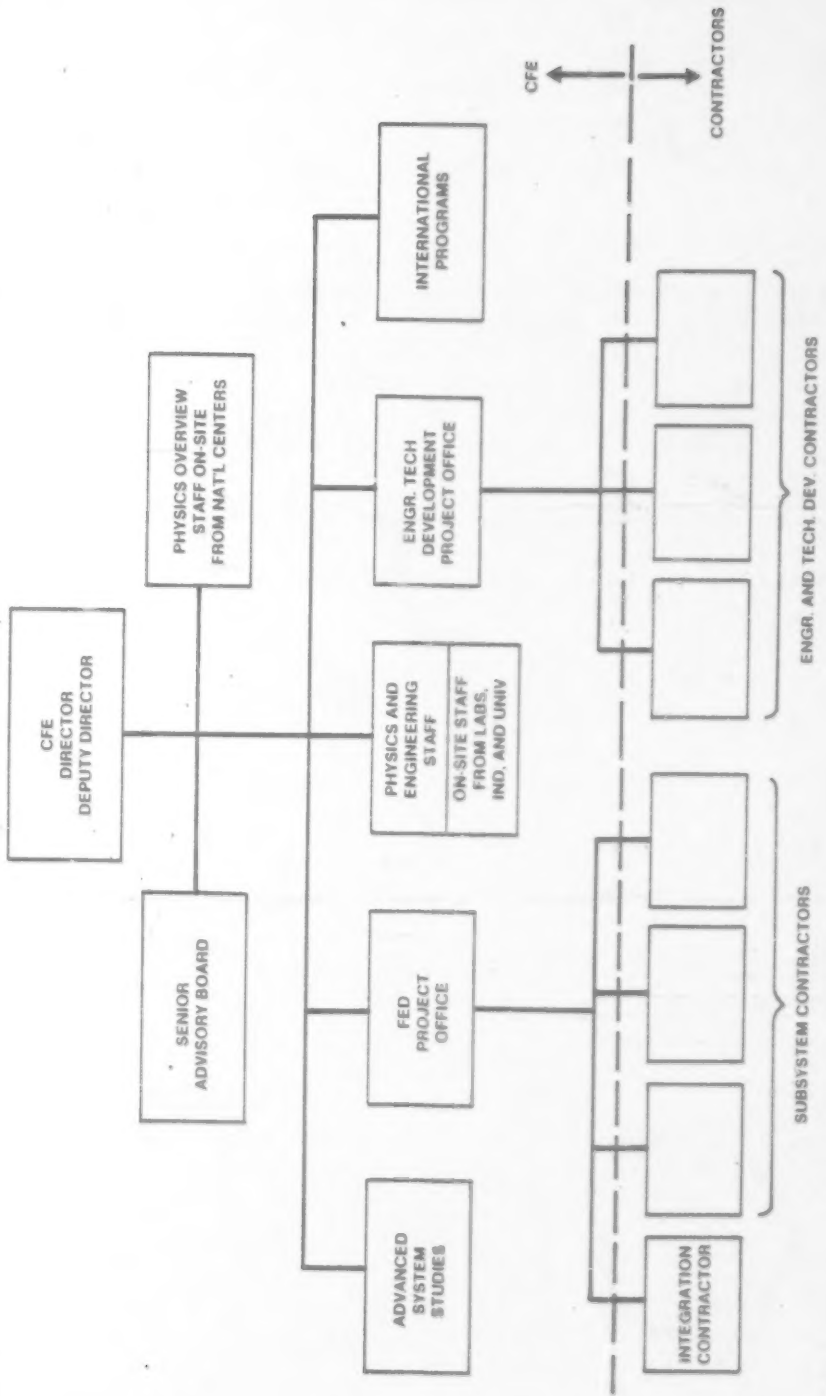
nally, the systems contractor was structured into a set of program offices, which implemented these programs, and into a set of technical specialty areas that provided technical assistance to the program offices and formulated and overviewed advanced technology programs.

I would like to suggest to the panel that this scheme may form a model for the structure of CFE. Certainly it is not the only model, but it is one model that perhaps offers some advantages which ought to be examined.

May I have my chart? A structure for the CFE modeled along the lines of the ballistic missile program is shown here. Again let me emphasize that it is only one of the many ways one could do this. The major elements of the CFE are two project offices, the project offices that have the various contractors reporting to them. These project offices oversee the implementation of the design and of the construction by various industrial contractors.

[The chart mentioned follows:]

ATTACHMENT I
SUGGESTED ORGANIZATIONAL STRUCTURE FOR CFE



In the center, there is a technical support staff provided both by the CFE contractor himself and also by staffs invited from the national laboratories, other industrial firms, and universities. The staffs will provide the CFE with ready access to the entire broad capability within the country that already exists and ought to be utilized.

There is, on our left, an advanced systems group. That group would perform reactor systems studies and would define the advance systems requirements which might go beyond the FED.

There is a physics overview staff on the right side, up above, which should be drawn from the national laboratories and which would provide an overview of all the physics that would go within the FED. This ought to be again a permanent group colocated with the CFE.

Finally, an advisory board, up above also, which would be composed of senior members of the fusion community. The purpose of that group is for reviewing the overall CFE operations and advising the director on the operation of CFE.

The onsite staffs, both the physics overview and also the central onsite staffs that I show on that chart, provide a close coordination with the ongoing fusion-physics program and also provide the CFE with expertise in physics that is otherwise very difficult to get. This arrangement then, in my mind at least, overcomes one of the major objections often raised against an industrially-led CFE, namely, that industrial firms lack the requisite physics capabilities today.

A second major objection to an industrial CFE is that the CFE contractor faces a conflict of interest if it participates both as leading the CFE and also as a contractor in the accomplishment of fusion engineering activities. This can be easily resolved by the CFE contractor accepting an exclusion from all work which is controlled through the CFE. The onsite industrial people that are shown on my chart would not face the same conflict of interest issue because they are isolated from the project offices. These project offices are the only ones that are actually doing the implementing.

Other than the project office personnel, everybody else would still be able to participate, but would be isolated from conflict of interest.

In summary, I would like to emphasize to you the following points:

First, I urge the panel to recommend proceeding with the establishment of a management structure for the fusion engineering program at the earliest possible date. In effect, what I am asking this panel to do is to recommend that the Department of Energy be held to a meaningful response in the requirements already embodied in the Magnetic Fusion Energy Engineering Act of 1980.

Second, the comprehensive engineering program should in fact be managed by a new national center, the CFE, created specifically for that purpose.

Third, the CFE should be industrially managed.

And, fourth, there are many management structures for the CFE—and I have given one of them a little bit earlier—which are functionally sound, which provide access to the best physics and en-

gineering capabilities across the board and which maintain a close liaison with the fusion physics program, and which also avoid any conflict of interest on the part of the CFE contractor.

[The prepared statement of Dr. Peter Staudhammer follows:]

Statement to the
Advisory Panel on Fusion Energy
Energy Research and Production Subcommittee
Committee on Science and Technology
U. S. House of Representatives

June 29, 1981

By

Peter Staudhammer
TRW Inc.

Mr. Chairman, members of the Panel, I am honored to have the opportunity to appear before you as you consider issues surrounding the management of the national fusion engineering program and in particular the Center for Fusion Engineering (CFE).

Convening of the Advisory Panel at this time is especially significant because the future of the magnetic fusion program may well be in jeopardy. In spite of the significant recent successes of magnetic fusion and in spite of the passage of the Magnetic Fusion Energy Engineering Act of 1980, the proper continuation of the fusion program is in jeopardy because of lack of proper funding, but perhaps even more so because of lack of commitment to the engineering development phase.

It may well be that the larger commitments in fusion engineering, such as the Fusion Engineering Device, can not be made at the present time due to tight budgetary pressures. However, there is all the more reason to put the management structures in place that can scope and plan the comprehensive fusion engineering development program. I urge this Panel to recommend that the appropriate management structure be established at the earliest practicable time.

Now, let me address the management structure for the engineering program. The basic concept of the CFE was proposed by the Fusion Review Panel of ERAB and is embodied in the Magnetic Fusion Energy Engineering Act of 1980. I believe this concept is a good one because it fills a very definite need.

The current fusion research program is well managed by DOE in a decentralized manner. However, the fusion program is now turning from research—characterized by a step by step evolution—to engineering development, which is characterized by definite goals and highly complex, but nevertheless highly integrated, programs. Such a complex but highly integrated program requires a strong central management organization that is capable both to manage and to technically understand and direct the program. Creating a new national center, the CFE, which can concentrate the right talent from across the country, is an ideal way of accomplishing this end.

Building an organization offering both the required technical talent and strong management orientation is best accomplished in an industrial environment. Industry has traditionally played such a role in major programs in the U.S. and has a good track record in its ability to manage complex, high technology programs. Industry can offer incentives to attract the most highly qualified management staffs and is able to staff and de-staff in accordance with program requirements. In turn, the government retains control over the industry through profit incentives and through the prospect of eventual commercialization.

An example of a complex, high technology program, which has many parallels with fusion, is the development of ballistic missiles. As in fusion today, there was in the late Fifties a strong consensus that ballistic missiles should be developed, but much of the technology and in some cases the basic physics understanding was missing. As in fusion today, several parallel paths of research and development were pursued in critical areas. Some work was done in military arsenals and national laboratories, though most development was done by industrial contractors. The responsibility of technically coordinating the large number of interrelated program elements was given to an industrial firm (Space Technology Laboratories) who acted as the systems engineer and technical director.

The main task of the systems engineering/technical direction contractor was to provide overall plans and system specifications, to define a set of subsystems which could be developed by separate contractors, to set subsystem performance requirements and interfaces, and to technically overview and direct the individual contractors. Internally, the systems contractor was structured into a set of program offices, which implemented the programs, and into a set of technical specialty areas that provided technical assistance to the program offices and formulated and overviewed advanced technology programs. I would like to suggest to the Panel that this scheme may form a model for the structure of CFE. Certainly this is not the only possible model, but it is one that offers many advantages.

A structure for the CFE modelled along the above described lines is shown in Attachment I. The chart includes only the main functional elements. Support services are not shown. The main elements of the CFE are:

- Two project offices, one for the FED and the other for engineering technology development. These project offices oversee and implement design, development, and construction at various industrial contractors.
- A technical support staff, provided partially by the CFE contractor and partially by on-site staffs from national labs, industrial firms, and universities.
- An advanced systems group that performs reactor system studies and defines advanced systems requirements.
- A physics overview staff, on-site from national fusion centers, that provides an overview of all physics activities of the CFE.
- An advisory board, composed of senior members of the fusion community, for the purpose of reviewing the overall CFE operations and advising the director.

The on-site staffs from the national fusion centers provide both a close coordination with the ongoing fusion physics program and also provide the

CFE with expert capability in physics. This arrangement overcomes one of the major objections often raised against an industrially-led CFE, namely, that industrial firms generally lack the requisite physics talent.

A second major objection to an industrial CFE is that the CFE contractor faces a conflict of interest if it participates as a contractor in the fusion engineering development program. This is resolved by the CFE contractor accepting an exclusion from all work controlled through the CFE. The on-site industrial staffs do not face this conflict of interest issue, as they are isolated from the project offices, which are the implementers of all contracting activities.

In summary, let me re-emphasize the following points:

- (1) I urge the Panel to recommend proceeding with the establishment of a management structure for the fusion engineering program at the earliest date.
- (2) The comprehensive engineering program should be managed by a new national center, the CFE, created for that specific purpose.
- (3) The CFE should be industrially managed.
- (4) There are management structures for the CFE—I have given one—that are functionally sound, that provide access to the best physics and engineering capabilities across the board, that maintain a close liaison with the fusion physics program, and that avoid any conflict of interest issues on the part of the CFE contractor.

Mr. REICHLER. Thank you, Pete.
The next speaker is Martin Scholl.

STATEMENT OF MARTIN M. SCHOLL

Mr. SCHOLL. Mr. Chairman, thank you for the invitation to speak to you today.

Since its formation in 1958, the MITRE Corp. has been fulfilling the role of systems engineer on major Federal programs. Many of these programs have either been for the Department of Defense or the Federal Aviation Administration. For example, the systems engineering of the Nation's en route air traffic control system, presently staffed at about 80 people within MITRE, has been a role that we have been carrying on for the past 10 years.

The projects themselves range to several billions of dollars of Federal investment for systems primarily for Government or quasi-Government use. The scope of MITRE's involvement has included task engineering for major subsystems through complete systems engineering and program integration at all management levels. MITRE's level of effort in these programs has been on the order of 10 to about 100 technical staff.

The major project manpower for detailed design engineering, construction, and operation have been supplied through normal industrial sources.

MITRE has unique institutional characteristics. It is an independent, not-for-profit corporation directed to work in the public interest. Except in a few specific cases for regulated energy utilities, MITRE will not work for commercial organizations nor compete formally against them, nor will it manufacture hardware or software. These characteristics allow MITRE to maintain a position of having no real or implied organizational conflict of interest and have allowed it to effectively carry out this role working with industry and government.

During the past year, MITRE has undertaken a modest, internally funded research and development project to determine if its systems engineering skills and experience could be applied to the DOE fusion program. Focus has been placed on a major review of Tokamak subsystem technology to determine the present degree of design and program implementation risk associated with scale-up to FED-type devices. In addition, a rigorous methodology has been developed and tested to identify physical interactions between Tokamak subsystems and then to assess the degree of engineering knowledge and risk in moving toward the next step in Tokamak design.

The preliminary results of this project, although still in review, indicate several interesting gaps in the understanding of design interactions and how they will affect the total system. But, perhaps more importantly, these results have indicated the need for a rigorous systems engineering approach in the next stage of Tokamak development. For certain, it is early enough in the development of the next major Tokamak device to significantly enhance its likelihood of success.

In the course of our work over the past several years, we have begun to understand several common pitfalls which cause major

projects to be less than fully successful. These include the following: Goals being too ambitious and not well specified, especially relative to system performance, schedule, and cost; design objectives not fixed early in the system development; critical subsystems not proven, either technically or at the scale required for major development; subsystem interfaces not adequately understood and/or specified; test and evaluation plans generally looked at as an afterthought, rather than integrated into the whole process; inadequate management monitoring and reporting; inadequate change control and configuration management; insufficient attention to secondary factors such as environmental, health and safety, permitting and licensing, and labor, materials and manufacturing needs; inadequate attention to startup, evaluation, and operation; contractor interfaces not well understood or managed; funding discontinuous or insufficient for objectives; and public support not well developed.

Many specific examples may be cited from a broad spectrum of programs which have not fulfilled their original objectives, having been late or over budget due to one or more of these reasons. Although definitive plans covering each of these issues need not be formulated at the outset of a project, it is most important to understand what is not known and to specifically allow for project uncertainties and risks. The next step in Tokamak development will, by definition, be confronted with such uncertainties and risks.

Often the experienced systems engineer working with Government planners and project managers can reduce and/or eliminate many of these problems. In this role, the systems engineer can carry out many of the following functions: Requirements analysis; preliminary specifications for the system, including the conceptual design and preproject plan from initial specification to decommission; baseline costs and performance scheduling; technology readiness evaluation and R. & D. needs specification—in the case of the Tokamak system, the R. & D. program must be to some extent governed by the development of the FED and the results of this program fed immediately back into FED design and development; subsystem interface analysis and documentation—that is another such role, as is this; acquisition strategy formulation and documentation; evaluation of technical proposals; acquisition support; preparation of test and evaluation plans; design reviews and review of contractor test documentation; where appropriate, the witnessing of test and analyzation and evaluation of data; evaluation of changes and maintenance or assurance of configuration management systems; the conduct of risk analysis; and the provision of technical direction and contractor interface.

When these roles are carried out successfully, the Government is more likely to acquire a workable device or system and the industrial parties involved are likely to be confronted with fewer false starts and difficult changes, and less than optional project results.

The systems engineer for the fusion energy program need not be a large or highly visible group. It should, rather, be a group with management orientation, experienced in large projects, and with an engineering mission orientation to assist DOE's Office of Fusion Energy. Among other disciplines, the systems engineer should have staff experienced in plasma physics, electrical engineering, mechanical engineering, and other engineering disciplines; project

management, configuration management, cost control and risk assessment, test and evaluation planning, R. & D. planning, system startup and evaluation, and environmental and health and safety analysis.

To effectively carry out this task, the systems engineer should have no real or apparent conflict of interest and in a sense, by carrying out its role, it should not have the opportunity to gain a competitive advantage in future commercial fusion energy systems.

Last, and of equal importance for fusion energy development, the systems engineer should be able to work openly and effectively with a variety of advanced Government planners, industrial concerns, and the highly talented staff at fusion R. & D. centers and universities.

[The prepared statement of Martin M. Scholl follows:]

ENERGY RESEARCH AND PRODUCTION SUBCOMMITTEE'S
ADVISORY PANEL ON FUSION ENERGY

SYSTEMS ENGINEERING FOR FUSION ENERGY DEVELOPMENT
Martin M. Scholl
THE MITRE CORPORATION

Since its formation in 1958, The MITRE Corporation has been fulfilling the role of systems engineer on many major Federal programs. Most of these programs have been either for the Department of Defense or the Federal Aviation Administration. The projects themselves range up to several billion dollars in government investment for systems primarily for government or quasi-government use. The scope of MITRE's involvement has included task engineering for major subsystems through complete systems engineering and program integration at all management levels. MITRE's level of effort in these projects has been on the order of ten to about one hundred technical staff. The major project manpower for detailed design engineering, construction and operation have been supplied by normal industrial sources.

MITRE has unique institutional characteristics. It is an independent not-for-profit corporation directed to work in the public interest. Except in a few specific cases for regulated energy utilities, MITRE will not work for commercial organizations or compete formally against them, nor will it manufacture hardware or software. These characteristics allow MITRE to maintain a position

of having no real or implied organizational conflict of interest, and has allowed it to effectively carry out this role working with industry and government.

During the past year, MITRE has undertaken a modest, internally funded research and development project to determine if its systems engineering skills and experience could be applied to the DOE Fusion Program. Focus has been placed on a review of major Tokamak Subsystem technology to determine the present degree of design and program implementation risk associated with scale up to an FED type device. In addition, a rigorous methodology has been developed and tested to identify physical interactions between all Tokamak Subsystems and then to assess the degree of engineering knowledge and risk in moving toward the next step in Tokamak design.

The preliminary results of this project, although still under review, indicate several interesting gaps in understanding of design interactions. But, perhaps more importantly, these results have indicated the need for a rigorous systems engineering approach to the next stages of Tokamak development. For certain, it is early enough in the development of the next major Tokamak device to significantly enhance its likelihood of success.

In the course of our work over the past several years, we have begun to understand several common pitfalls which cause major projects to be less than fully successful. These include:

- o Goals too ambitious or not well specified
 - performance
 - schedule
 - cost
- o Design objectives not fixed
- o Critical subsystems not proven
 - technically
 - at required scale
- o Subsystem interfaces not adequately understood and/or specified
- o Test and evaluation plans an after-thought
- o Inadequate management monitoring and reporting
- o Inadequate change control and configuration management
- o Insufficient attention to secondary factors
 - environmental, health and safety
 - permitting and licensing
 - labor, materials and manufacturing needs
- o Inadequate attention to start-up, operation and evaluation
- o Contractor interfaces not well understood and/or managed
- o Funding discontinuous or insufficient for objectives
- o Public support not developed

Many specific examples may be cited from a broad spectrum of programs which have not fulfilled their original objectives, have been late or over budget due to one or more of these reasons. Although definitive plans covering each of these issues need not be formulated at the outset of a project, it is most important to understand what we don't know and to specifically allow for project uncertainties and risks. The next step in Tokamak development will by definition be confronted with such uncertainty and risk.

Often the experienced systems engineer working with government planners and project managers can reduce and/or eliminate many of these problems. In this role, the systems engineer will carry out many of the following functions.

- o Requirements analysis
- o Preparation of systems specification
 - conceptual design
 - complete project plan (initial specification to commissioning)
 - baseline costs and schedule
- o Technology readiness evaluation and R&D needs specification
- o Subsystem interface analysis and documentation
- o Acquisition strategy formulation and documentation
- o Evaluation of technical proposals
- o Acquisition support
- o Preparation of test and evaluation plans
- o Design reviews; review of contractor test documentation
- o Witness tests; analyze and evaluate data
- o Evaluate changes and maintain configuration management system
- o Conduct risk analysis
- o Provide technical direction and contractor interface

When these roles are carried out successfully, the government is more likely to acquire a workable device or system and the industrial parties involved are likely to be confronted with fewer false starts or difficult changes and less than optional project results.

The systems engineer for the fusion energy program need not be a large, highly visible group. It should rather be a group with a management orientation, experienced in large projects and with an engineering mission orientation to assist DOE's Office of Fusion Energy. Among other disciplines, the systems engineer should have staff experienced in plasma physics, electrical engineering, mechanical engineering, and other engineering disciplines; project management, configuration management, cost control and risk assessment, test and evaluation planning, R&D planning, system start-up and evaluation, and environmental, health and safety analysis.

To effectively carry out its tasks, the systems engineer should have no real or apparent conflict of interest and in a sense, by carrying out its roles, should not have the opportunity to gain a competitive advantage in future commercial fusion energy systems. Last, and of equal importance for fusion energy development, the system engineer should be able to work openly and effectively with a variety of advanced government planners, industrial concerns, and the highly talented staff at fusion R&D centers and universities.

Mr. REICHLER. Thank you very much.

Our final speaker for this last panel will be Don Anthony.

STATEMENT OF DR. DONALD J. ANTHONY

Dr. ANTHONY. Mr. Chairman, members of the Fusion Advisory Panel, ladies and gentlemen, it is nice to be last, because it has all been said, but I still would like my time.

In addition to being Manager of the Fusion Energy Systems at General Electric, I also have the responsibility for coordinating all fusion programs within the General Electric Co.

General Electric began its activities in fusion back in the classified days of the early 1950's in Project Sherwood. In 1956, when there was a commercialization program for fusion begun and you could get a license for \$300, we started some R. & D. work, and studied the theta pinch concept.

What you are looking at is a first demonstration of the theta pinch concept. That little demo reactor was set up at the 1965 World's Fair, where we produced 108 fusion events from a DD reaction, so GE goes back a long ways in fusion R. & D.

Currently we are involved in the Large Coil Program, and you see one of our winding facilities in our turbine manufacturing operation in Schenectady. We will deliver that 8-tesla coil in 1981 to Oak Ridge for test. We are involved in the Fusion Engineering Design Center in the electric systems and magnet systems and to a lesser extent in plasma systems. We have been involved in technology studies and assessments in the neutral beam and RF plasma heating systems, the large 12-tesla coil development program, and we participated in phase 1 design studies of the Elmo Bumpy Torus.

It need not be said, because it has been said already several times today, that there is a good consensus that fusion is ready for some engineering development. That's what we have been talking about.

My first recollection of someone coming to bat was the Fusion Power Coordinating Committee at the Princeton meeting in April 1979, where it was stated that fusion physics progress was going along at a pretty good clip and that it's time we started thinking about the engineering aspects. That was in 1979. Following the FPCC recommendation we have the advisory panel here—and your predecessors—the ERAB panel, the Atomic Industrial Forum and, of course, the Magnetic Fusion Energy Engineering Act of 1980.

I really believe that fusion could be made to work scientifically. The challenge is really: Can you make it a cost-effective energy system?

When I talk about cost-effective, I also include environmentally acceptable, because that has a strong bearing on cost, as we all know from the fission reactor business.

I feel it can be made to work, because the laboratories have done an excellent job in physics, and when you look at all of the projections and the Lawson criterion, we are approaching the promised land of the fusion reactor regime. I think that will happen. I don't have any doubts about that.

But can you make it a viable, cost-effective system? That's our challenge.

On that basis, then, I state that the fusion development program needs to develop the industrial partners. While there has been an effort in the United States to proceed along these lines, the problem that we all face, and many of us in industry have gone through this, we need a supported basis, a sustained basis, and not hit or miss, where you put a project together, engineers and technicians and even your hourly people, and you establish the team for 6 months or a year or 2 years, and then you disband and you lose all of that technology and expertise because of the lack of sustained funding.

Industry, obviously, as has been said several times today, does contribute and can contribute considerable technical skills to marry with the laboratory scientific and technical personnel, the plasma physicists and plasma engineers in designing and developing hardware and the manufacturing aspects, since manufacturing plays a very important role in whether you ever have a cost-effective system.

Operation and maintenance, that's not an afterthought. That has to be factored in early in a design program, as many of you already know, and we hope eventually will be ready for commercialization down the road.

But industry people have done this. Those are the kinds of talents that industry can blend with the laboratory personnel to make fusion energy a real possibility in the United States.

Fusion energy—we say this over and over again—that the payoff is potentially very great. It can help solve the long-term energy problem.

We talk about energy security. And I think in the United States, because of the absence of the gaslines, people think that we are well on the road to energy security. No gaslines, and the OPEC, having leveled off on the prices, at least we have got a brief hiatus in the cost per barrel of oil. But that is not going to last, nor is anyone smart enough to predict the political, social and economic factors that can influence the availability of energy.

Boil all this down and it says that fusion is an option that the United States should have, and we are not going to get it at the rate we are going.

Fusion development is a program that is well suited to major Government funding. It is a high-risk, long-term development. Industry will not belly-up to the bar with large significant internal company funding at this point.

I have three recommendations that I just want to mention and then enlarge upon.

There is a question in my mind that you can have a CFE, Center for Fusion Engineering, without the Fusion Energy Device as a focal point.

The best magnetic confinement candidate device, of course, is the Tokamak right now. We are talking about an engineering device. If it is a Tokamak and it has the capability of operating at a couple of hundred megawatts level, then you can get a true engineering test. The fusion engineering technology will be applicable and could be

used for mirrors or Elmo Bumpy Torus, or any other device that comes along where you are burning DT.

The FED construction should be split into multiple subsystems contracts to broaden and increase the industrial participation, and also that eventually the FED and the CFE should be collocated.

In the interim, to get on with this program—and it is complex, as many people have said—let's establish the FED mission and schedule. Let's fund and strengthen the Fusion Engineering Design Center, already in existence, in order to develop the conceptual design and a base line cost so that you could go out for procurements for the FED project.

In that last organization box, industry is already involved, use them. There are many industrial participants in the Fusion Engineering Design Center.

Now, finally, this is a recommended DOE/CFE organizational chart which is going to raise questions. Because how do you get there? It would be nice to have a time sequence to show how this thing falls into place. But down the road I can envision the following: That there is a Center for Fusion Engineering and there are National Lab programs, which will continue for quite a few years, and will report in somewhere in the Department of Energy.

I have Ed Kintner up there, Office of Fusion Energy.

Now, from the Center for Fusion Engineering standpoint, I recommend that eventually the Design Center, made up of industry and the Lab people, should in some form move over under the Center for Fusion Engineering.

You will note that the National Labs are still participating in various functional blocks, and have been designated by asterisks. Either the labs can be funded directly from DOE or their funds flow from the Center for Fusion Engineering. That is not a decision you have to make today.

Now, you slip over to the right, and you look at the Fusion Engineering Device, and I recommend that you have a contractor for construction integration, and he then subcontracts and he has a number of industrial participants who bid on the subsystems in order to broaden the industrial base. The development program and specifically the FED developments, can be supported by the National Labs.

Another point that is not obvious from that chart is that there are a lot of development programs in progress that support the Design Center, the Development and Technology DOE programs.

There are also existing facilities that are working on bits and pieces that are required for the engineering development. I propose to leave those where they are located, and any new development facilities could be put under the Center for Fusion Engineering.

So that is why I say that is a composite. That chart is where you would end up, at least that is one way. It is not shown on real time because all of this has to come about in a stepwise fashion. But my main message is that the Fusion Engineering Device should be the focal point for the Center for Fusion Engineering.

Thank you.

[The article "A Presentation to the Fusion Advisory Panel by Dr. Donald J. Anthony" is as follows:]

A Presentation to the

FUSION ADVISORY PANEL

of the

UNITED STATES HOUSE OF REPRESENTATIVES

**SUBCOMMITTEE ON
ENERGY RESEARCH AND PRODUCTION,
HOUSE SCIENCE AND TECHNOLOGY COMMITTEE**

June 29, 1981

by

**DR. DONALD J. ANTHONY, MANAGER
FUSION ENERGY SYSTEMS
GENERAL ELECTRIC COMPANY**

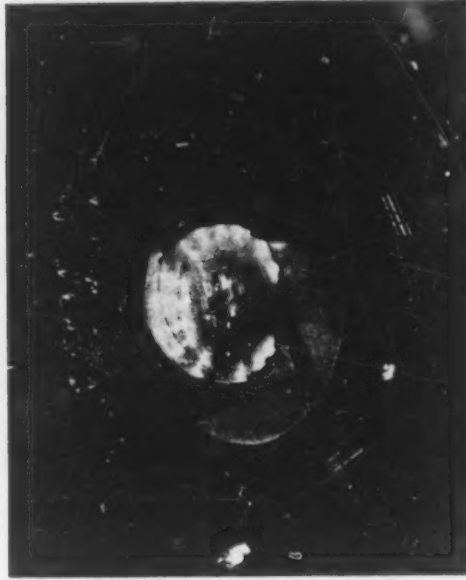
GENERAL  ELECTRIC



GENERAL ELECTRIC — PIONEER IN FUSION R&D

■ PROJECT SHERWOOD (CLASSIFIED)
— EARLY 1950's

■ THETA PINCH R&D
(COMPANY FUNDED)
— INITIATED - 1956



FIRST WORKING DEMONSTRATION
OF A FUSION REACTOR



CURRENT GENERAL ELECTRIC FUSION ACTIVITIES

- LARGE COIL PROGRAM
 - WILL DELIVER FIRST 8T COIL IN 1981
- FUSION ENGINEERING DESIGN CENTER
 - ELECTRICAL SYSTEMS
 - MAGNETIC SYSTEMS
 - PLASMA SYSTEMS
- RECENT TECHNOLOGY ASSESSMENTS/STUDIES
 - NEUTRAL BEAM SYSTEMS
 - RADIO FREQUENCY HEATING SYSTEMS
 - 12 TESLA SUPERCONDUCTING MAGNET
 - ELMO BUMPY TORUS-P (PHASE 1)





FUSION IS READY FOR ENGINEERING DEVELOPMENT

THIS CONCLUSION IS SUPPORTED BY

■ FUSION POWER COORDINATING COMMITTEE	4/79
■ HOUSE SUBCOMMITTEE FUSION ADVISORY PANEL	12/79
■ ENERGY RESEARCH ADVISORY BOARD	8/80
■ ATOMIC INDUSTRIAL FORUM	2/81
■ MAGNETIC FUSION ENERGY ENGINEERING ACT	1980



FUSION CAN BE MADE TO WORK SCIENTIFICALLY

112

**OUR CHALLENGE
IS TO**

MAKE FUSION ENERGY COST-EFFECTIVE



FUSION NEEDS INDUSTRIAL PARTNERS

113

- MUST DEVELOP U.S. INDUSTRIAL BASE
 - SUPPORTED WITH SUSTAINED FUNDING
- INDUSTRY CAN CONTRIBUTE CONSIDERABLE TECHNICAL AND MANAGERIAL SKILLS FOR
 - DESIGN AND DEVELOPMENT
 - MANUFACTURING
 - OPERATION AND MAINTENANCE
 - COMMERCIALIZATION



FUSION ENERGY . . .

- CAN HELP SOLVE NATION'S LONG-TERM ENERGY SUPPLY PROBLEM
- IS A LONG TERM, HIGH RISK DEVELOPMENT
- IS WELL SUITED TO MAJOR GOVERNMENT FUNDING FOR DEVELOPMENT



RECOMMENDED INTERIM ACTIONS

- ESTABLISH FED MISSION AND SCHEDULE
- FUND AND STRENGTHEN FUSION ENGINEERING DESIGN CENTER TO
 - ESTABLISH A FED CONCEPTUAL DESIGN
 - PROVIDE BASELINE COST ESTIMATES IN PREPARATION FOR THE FED PROCUREMENTS

INDUSTRY IS ALREADY INVOLVED — USE US !

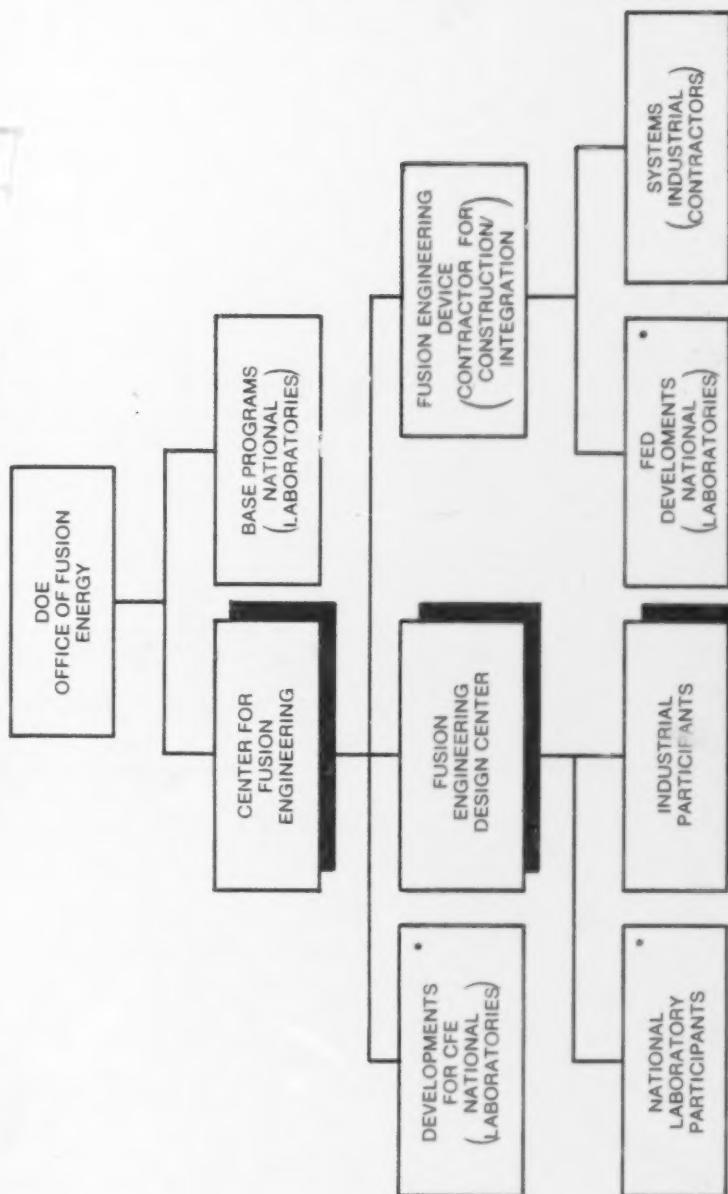
RECOMMENDATIONS

- FUSION ENGINEERING DEVICE (FED) SHOULD BE THE FOCAL POINT OF THE CENTER FOR FUSION ENGINEERING (CFE)
- FED CONSTRUCTION SHOULD BE SPLIT INTO MULTIPLE SUBSYSTEM CONTRACTS TO INCREASE INDUSTRY PARTICIPATION
- FED AND CFE SHOULD BE COLLOCATED





RECOMMENDED DOE/CFE ORGANIZATIONAL STRUCTURE



* THE NATIONAL LABORATORY CONTRACTS COULD COME FROM DOE/CFE AS AT PRESENT

Mr. REICHLE. Thank you, Don.

I would like to start questions by asking one of you, Don.

Assume we went in the direction of the chart you have on the board. Would you visualize any conflict in program planning and control between Ed Kintner's Office of Fusion Energy and the CFE?

How would you avoid overlapping or duplication?

Can you clearly identify the relative functions? Or how do you look at that?

Dr. ANTHONY. Between the DOE organization and the—

Mr. REICHLE. Between the DOE and the CFE.

Dr. ANTHONY. The DOE organization will have to monitor the CFE and it will need to have a sufficient staff to be able to exert some influence on the National Lab programs, as well as CFE. And whoever is operating the DOE Office of Fusion Energy has to have a sufficient staff and manpower talent to be able to judge, as somebody brought up earlier today that the industrial contractor or the consortium is doing the right job in conducting the fusion national development program.

So I don't see a conflict because it can be worked out.

Mr. REICHLE. I assume you mean monitoring both technically and financially—

Dr. ANTHONY. Yes.

Mr. REICHLE [continuing]. In the interest of making sure that the Government's money is properly being spent; is that correct?

Dr. ANTHONY. Find a way for the CFE to administer the contracts and the subcontracts. So the CFE should have a very strong technical and engineering organization, no question. They should have a strong legal, financial and contractual procurement organization in order to carry out its mission if you are going to put real bucks into it. It is not a token organization, in my mind.

Mr. REICHLE. Thank you.

Other members of the panel, do you have any questions or comments?

Dr. LANDIS. Maybe I could ask one about the organization.

In looking through the charts, Dr. Anthony and Dr. Staudhammer, I get the feeling that what you are proposing, from the organizational charts, is essentially the same kind of organization, with some minor differences.

Do you both feel that way?

Dr. ANTHONY. I think I understand Pete's chart. I don't know if he had the CFE as strong an organization as I proposed.

Dr. STAUDHAMMER. Well, I thought there were some major differences, in that I saw the CFE as being the central strong, technically strong, as well as managerially strong, organization that coordinates a large, broad set of programs.

It is not specifically for the FED. The FED is just one part of it.

I further see the CFE breaking the FED into major subsystems and seeing that these major subsystems in fact are developed at the right places across the country rather than entrusting the entire FED just to one organization alone.

I also see a lot of feasibility research programs going on. I see a considerably more complex picture than Dr. Anthony.

Dr. EVANS. Someone on the previous panel mentioned it would be a disaster if there were, say, 5,000 people rather than, say, 50 people in the CFE.

How many people do you conceive in the organization you discussed?

Dr. STAUDHAMMER. I see both the 50 and the 5,000 being a disaster. I think it has to be in between the two. Probably in the order of 500 to 1,000. Something like that.

You know, one can't really decide on that unless you really consider what the program is, which depends on the pace of the national program.

How much money do we have? Do we have \$400 million next year? Or do we have a billion dollars? That makes a big difference.

Dr. EVANS. With respect to Mr. Scholl's comments about the hindsight disasters, with respect to excessive risk taking, funding, and so forth, I just saw this famous budget a few minutes ago, and I wonder how anybody in the CFE could avoid that financial risk taking? We look at France admiringly in the breeder business, where there are extrapolations that will blow your mind.

For example, 17 to 750 megawatts. And I wonder how the CFE would reduce those examples of excessive risk taking.

Mr. SCHOLL. The critical issue that we have seen in the past is understanding those risks rather than moving ahead blindly. We have found that, for example, in several of the present synfuels program projects, where large and rapid scaleups were incorporated, certain aspects of the technology were not looked at in their full-scale form, or where standard technology was going to be married with advanced technology, the full-scale implications of the integrated systems were not well understood. The result led to budget problems, delays and, in a few cases, to cancellation of projects.

A systems engineering organization—and I want to emphasize systems engineering and not the CFE—with experience in controlling and managing such projects, taking into account the uncertainties and the risks in that management, is what I feel is the critical element.

We have been talking about roles of the CFE. I think, as you noticed, I didn't mention CFE at all in my prepared testimony. Systems engineering is a critical role in the fusion energy program, a role that needs to be fulfilled. It is not clear to me whether that role should be performed within a CFE, which may have a lot of political visibility and strains, or whether it should be performed within the Department of Energy or by some other independent contract organization. But it is a critical role. It is a role that has been talked about as one of the roles of the CFE during the course of today. And perhaps one which needs to be carried out, not in conflict with the present industrial structure or the present research going on within Federal laboratories, but rather in consort with them.

Dr. ROSENTHAL. If an early decision were made to go ahead with CFE, I wonder if Pete or Don have some feeling as to what the time sequence would be, the speed with which one could bring into operation the organizations which you outline.

Dr. STAUDHAMMER. I think the two of us have had a little different view on that issue.

I am advocating that the country proceed with a decision toward commitment toward the FED and then put the CFE in place.

But given that such a decision is not made, it seems to me the only plausible thing left is to establish the management structure, the structure that defines what the FED will be and establish that.

I believe that you have to establish the CFE approximately during the next year, because we are already starting to get late for an FED by the end of this decade. The FED decision, I presume, would come in the 1984 budget.

If the FED decision does not come at that point, I think the entire program will just flounder for some more time.

Incidentally, I would see the CFE starting up initially like a 30-, 50-, maybe 60-man group, to begin with, and it would grow as the job in fact would grow. I don't think you start with 500 people right off the bat.

Dr. ANTHONY. Murray, with the budget restraints that we have, I am for using all of the money to develop the FED program, whatever it has to be, whatever national lab support you have, whatever industry support you have, you have to get the design of the device nailed down. You need the engineering development to support the fusion energy systems development.

I am saying that I don't see that there is a pressing need that you should go out with the Center for Fusion Engineering right now, when you don't have the funding to support it.

Mr. McCormack said, "Don't forget, this is an engineering device."

That's all we are talking about. We have got to get that going to support the plasma physics.

If you want to marry the physics and the engineering and come up with a cost-effective system, you have to have some program plans on how to proceed.

The power system will never look like what we are talking about today. If I am around long enough and if any of you are, it will never look like what we think it is today. But there will be a fusion energy reactor of sorts if it is in the cards, and we can make it. But you have to have more of an engineering base and you have to get over some of the nitty-gritty problems.

I keep talking about if you get into the technical area and talk about neutral beams, neutral beams as a plasma heating device, mechanically, is a tough thing to visualize in a commercial power reactor, opening a 3-, 4-foot-diameter gap of radioactivity and have a streaming path, you just can't do it. You can't accomplish it.

Now, is it RF? RF looks, mechanically, as a better suited system.

You have to design gyrotrons, you have to pump the RF into the plasma.

The Wall Street Journal had a big article Friday about millimeter radar developments.

We are talking about that in fusion. We need superconducting magnets that nobody has ever built that are as tall as this room. When are we going to get started? Are you going to push a button and say, "OK, industry, deliver me x toroidal field magnets," or get

some more yin-yang magnets for Ken Fowler at Livermore, he wants a half a dozen?

It is just not going to happen overnight.

So I say get on with the engineering, get the device design squared away.

Don't forget, I don't know how many of you recognize that some of us in industry have 4-year contracts to support the Design Center, where we were supposed to build up our staff in fiscal year 1981, 1982, and 1983. We are at ground zero. We are at the manning levels of fiscal year 1980 because, they tell us, of a lack of funds.

Now, how are you going to design the engineering device when you don't have the funds and you can't bring in the industry people you are supposed to nor the laboratory people you need to support and carry out the technology development program?

That's why I say the focus has to be the engineering device, Murray.

I am not for spending a nickel on the CFE until we have got a handle on that. It takes a year or two to do that. Let's do that first if you have limited funds.

Mr. McCORMACK. Don, who is going to manage this engineering program for the FED if we don't have a CFE?

Dr. ANTHONY. Who is going to manage it?

Mr. McCORMACK. Who is going to organize it, manage it, direct it?

Dr. ANTHONY. Maybe you have got to put together another team to do the management, an industry and laboratory team.

Mr. McCORMACK. This would be the beginnings, then, of the CFE, wouldn't it?

Dr. ANTHONY. Yes, You could call it a CFE—

Mr. SCHOLL. You could do that, Mike, but not necessarily calling it a CFE.

Mr. McCORMACK. OK.

Dr. ANTHONY. Maybe you take some of the companies that are there and put some of their management in there as a steering committee or as industrial advisory board with some of the laboratory people.

Dr. LANDIS. There was a trend we detected in the previous panel.

Mr. SCHOLL. I think there are some examples, not to dredge up old horses, but the formation of the Solar Energy Research Institute, as a focus for the future of solar energy, to provide some of the same functions that have been talked about for the CFE, doesn't seem to be the success that we thought it would be. The political implications surrounding the selection and operation of the Institute, the tortuous path that the management had to walk in order to maintain an organization with some degree of technical and management credibility, made it almost impossible for the organization to function in its originally defined role.

We might learn some lessons from that organization and not give the management or systems engineering organization for an FED quite the same burden.

Mr. SPENCER. I would like to comment on that, because I feel very strongly about that, having been on the National Academy Committee that originally wrote the functional specifications,

which did not get implemented by DOE. That is what really scares me, is that—and people do know how you should manage new organizations, but when the implementation occurs, it often falls apart.

I take some exception to Dr. Anthony. I believe you need a focused organizational responsibility first, and then an FED; but I do believe that SERI is an example where they did not have a clear mission orientation, and without a clear mission orientation they floundered.

So what we really need to do, I think both—maybe not simultaneously, but very close on one another—but I do think you have to have a centralized organization that is responsible and their tails hanging out there, if you like. That's my view.

Mr. McCORMACK. May I just say I can't let the comments about SERI go—

Mr. SCHOLL. There were other problems.

Mr. McCORMACK [continuing]. Because I would like to say that I think the management of SERI did have an objective. This was a totally different objective that was called for in the law.

Mr. SCHOLL. Yes.

Mr. McCORMACK. The purposes of SERI were totally prostituted under the Carter administration. I happen to have written the law for SERI, as well as for the fusion program, and I called for a scientific research organization, not a propaganda antinuclear center, which it became under the Carter administration, which I think is very important.

But in the case of the Fusion Act, we are clearly specifying our goals, I think, and instead of saying, "Set up a research institute," which we set up for SERI, with a critical mass of manpower and equipment to do good basic research, that the law said to do. In this case we are setting out specific accomplishment goals instead. So there is a difference. I just wanted to make that point.

Mr. SCHOLL. I agree with you. The issue, though, relative to notoriety, limelight, and so on, could cause a CFE to become a political football, as to some extent SERI did.

Mr. McCORMACK. I don't think there is any absolute guarantee with respect to that until we have such overwhelming defined public support originating in the White House and going clear to the public, as we had in the Apollo program, where nothing will happen to it; we are not going to be safe from that sort of thing until we develop that sort of support.

So one of our goals has to be, of course, to appeal to the President for a sharply defined statement of support. And, as some of you mentioned, one of the rules of the organization has to be public information. Unfortunately, you can't have periodic spectacles in the fusion program, and we have always recognized this as a handicap. We have got to carry a program twice as long without them. This is why you need massive public support.

Dr. LANDIS. Mr. Chairman, we have heard differing opinions on what the management entity of the engineering phase should be called, how it should be organized. It seems to me that this panel reflects some of the same things that we have brought out, or that the last panel brought out, and that is that we need, first of all, a clear mission, what are we going to do, and then I think we need to break that mission down into specific goals and we need to estab-

lish from those specific goals just exactly how we are going to evaluate the management entity before that entity is chosen, because I think it is only fair that during the selection process the proposers for the management entity job be told what mission they should meet, what goals they are going to have to be judged on, and how the evaluation procedures are going to work; otherwise you are not going to have a meeting of the minds and you are going to have a hodge-podge after the thing is organized.

I think this panel—maybe I am reading it wrong—agrees with that.

Mr. SCHOLL. Definitely.

Mr. REICHLE. As to the relationship between SERI, the solar program, and fusion, it is probably fair to say that there was an order of magnitude of difference in the status of the technology. The solar program is trying to start from nothing, almost, whereas in the case of magnetic fusion, the Princeton Plasma Physics Laboratory has been at it 25 years, with many other laboratories participating.

Are there others? Ken, do you have any other comments?

Mr. BLATTNER. Let me try this for size one more time.

Mr. REICHLE. Yes.

Mr. BLATTNER. What if we make some assumptions? There are a lot of different thoughts about the total objectives of the CFE; but assume for a moment that we agreed that its primary goal was to promote the FED; we are going to start walking before we run and that CFE's function is a management one and it has technical expertise and it has to administer contracts. What kind of size does our panel now envision the CFE to have, with that less than 20 year role for the FED?

Dr. KUMMER. This is an immediate size, a get-started size?

Mr. BLATTNER. A limited time span, all the way up to FED.

Dr. KUMMER. I think to get started it is small, particularly in the light of what budget constraints we seem to face in the next couple years, and until we define the job mission and charter for CFE, it is pretty hard to define the size; but I think it is in a couple hundred people.

Mr. REICHLE. Don, how did you propose to keep the CFE from becoming too large and too complex?

Dr. KUMMER. Well, we suggested several possibilities. One is just an out and out manpower limitation, to say that it cannot be any bigger than this.

Another was our comment that it should be non-for-profit. That is one way to stop it from becoming a monster. If, indeed, it is small, that sort of takes away the profit motive. There is not much money to be made, anyhow, because it is small and what motivates the CFE organization to do a good job is for those companies to retain their image and to position themselves in the future. I think we are all in this for the future commercialization phase and not for the R. & D. phase. I remember in the early days of the Atomic Energy Commission, the first general manager, Ed Kintner remembers this, too, Carl Wilson said, "We are going to take a small building because we are never going to let ourselves grow more than to 127 people," and it just kept on growing. I think maybe a combination of factors would be the answer.

Dr. KUMMER. The basic shortage in what the CFE accomplishes with its own personnel probably is the most important thing to constrain its size and growth.

Mr. McCORMACK. May I ask now, the CFE mission, I think we all agree, is to come to a conclusion on schedule and conceptual design for an FED.

Dr. KUMMER. That is I think the initial mission.

Mr. McCORMACK. I mean, that is the initial mission, but by 1983 it has to have decided on a design, or at least a conceptual design for FED.

Now, what does it take to do that? Isn't that the governing parameter?

Dr. KUMMER. Well, I think that is going to be a real challenge for the CFE to do that by themselves. We do need to recognize that we have in place other groups that can help, like the technical management board that is in place now, as well as the design center at Oak Ridge. These should be valuable resources for any CFE that is chartered with the decision of the conceptual design by 1983.

Mr. SCHOLL. I tend to agree with that estimate of somewhere between 50 and 150 people, in light of Mr. Blattner's description of the major functions, with one exception. He included within those functions the procurement function in the sense of subcontracting for the development of the FED. That administrative function in itself probably requires several hundred people.

I would suggest that in most of the projects that we have been involved of a magnitude similar to the FED, that between 50 and 150 technical staff were assigned the project; but that major procurement actions were handled not through the corporation, but rather directly by the Government to the contractors involved. Procurement actions and ultimate cost control were maintained by the Federal Government. Under this assumption the staff can be limited to a reasonable number of highly qualified professionals.

Dr. ANTHONY. Well, let me try another scenario that I was alluding to with that chart. While we are talking about a Fusion Engineering Device today and I said the CFE and the FED should be colocated, suppose the next engineering device is a mirror device, OK? Where are you going to locate it?

Then suppose a couple years later that everything is looking great with one of these devices and you want a demo or a near demo. Where are you going to locate it?

Now, if you invest a lot of money in energy storage, energy supply, and you have built up development laboratories that are now meeting new criteria because you are now producing some kind of power in these engineering devices, it could be that the CFE is now a real national center for fusion energy development. The present national laboratories are transferring their people involved in fusion development as well as their budgets to the center until you are at a point where you are near commercialization. If fusion power is cost effective, industry takes over; so I am kind of leery of predicting any kind of numbers for what the CFE if it goes along those lines, I do not know how you predict what the numbers are; it could be a 5,000-man organization, but it is doing all the national development fusion and maybe it is even doing inertial con-

finement somewhere down the line. So there are several possibilities and to sit here and try to second guess where it is going to go, I think you are doing a disservice and I think you are also doing a disservice to say it is going to be 50 people or 100 people. If it takes 1,000 or 3,000 to do the job and fusion development is a real technical challenge, it takes 3,000 people to do the job, if we are serious about a fusion development commitment in the United States.

Dr. EVANS. Isn't it rather profoundly important to find out whether there is a difference of opinion between 50 and 150 and 5,000, and who knows how many more, that there is that range of figures?

Dr. ANTHONY. Sure; to start with, you know it is going to be small.

Dr. EVANS. Everybody agrees they are going to start small, from nothing, probably.

Mr. SPENCER. I would like to ask one more question of Dr. Anthony on the mission of the FED which I think you had in one of your recommended items.

When you say that, do you have in mind questioning whether electric power is the primary output from such a device?

Dr. ANTHONY. Not really. I sort of assumed, but it does not necessarily follow, that it would be electrical power production. Before we were talking about an engineering test facility and now we are talking about a fusion engineering device and whether we went from a more aggressive test device in ETF to a lesser test device, and less expensive, this is the way the program has been shifting and it represents some kind of waffling in the program, which does not do us a hell of a lot of good. That is what I am really driving at.

Mr. SPENCER. I thought perhaps we might want to even question the mission.

Dr. ANTHONY. I did not take that issue on. When I speak of fusion energy systems, I do not have to.

Mr. SPENCER. But that is an issue that has profound implications on whether Ken's configuration is first or second.

Dr. ANTHONY. Yes.

Mr. REICHLER. Are there further questions or comments?

Mr. CAIRNS. One of the problems in this whole area is the transition from here to there. You mentioned the question of the design center. How do you see that transition and when do you see the means of that developing into a whole design organization or if not, when would the transition be to the organization that ultimately has to deal with it?

Dr. ANTHONY. If you got to the stage where you had the base-line cost and you had a concept that you wanted competitive bids and after that is accomplished, you may want to move the design center, make the design center the technical arm for the FED construction. That is what I mean.

Dr. STAUDHAMMER. May I comment on that also?

Mr. REICHLER. Yes, please.

Dr. STAUDHAMMER. I think it is very important that the management structure be rather clean. One cannot have a technical management board and an advanced design center and an advanced development program, each going on at the same time, each with its

own office. The major function of the CFE is in fact to coordinate all that, rather than letting it go on separately.

Where does CFE belong? Why, it belongs to the Office of Fusion Energy with the rest of the program that is going on, where basic areas are being pursued. However, all the engineering should be under the one center; otherwise, you will have differing program elements and you are back exactly to the same problem as we have today, where one office within the Government has to do all that coordination and it cannot do it under the manpower limitations it currently has. If you have ever done any work in the details of decisions as to what kind of heating methods to use and particle control problems and so on, you frequently come to the conclusion that there is much more work there than meets the eye at first.

There is no way that 50 people today can put their hands around the entire FED and engineering development question, not to any degree of understanding. I think it has to be considerably larger.

Furthermore, I think it is a very important question for this panel to answer whether CFE is a 50-man group or 500. That is a fundamental problem. One cannot just say it will turn out what it does. That is the reason this whole thing is not going any faster, because we do not know in fact what there is to do.

I think we have to define where we are going and there is a big difference between a 50-man group and a 500-man group.

Mr. REICHLE. Any other questions or comments from the Panel?

Dr. DAVIDSON. Several of the industries represented by this particular panel have experience in defense systems. I wonder if we could get some comments on the first of Harold Agnew's prerequisites for the CFE; that is to say, the question of national commitment.

What in your opinion would constitute an adequate and serious national commitment if we really move ahead in the engineering phase?

Dr. STAUDHAMMER. A national commitment? I am not sure what you are referring to. Is it a commitment by the Government?

Dr. DAVIDSON. In the Defense Department, where certainly several defense systems are developed with a serious commitment, how far are we falling short of that in the fusion development field?

Dr. STAUDHAMMER. In a way, I do not see the big difference between the DOE and the DOD kind of commitments. There are commitments within DOD which are very unpopular, but nevertheless are made. They do not have any particular public support, but nevertheless are made and they are carried through, like ABM's, missiles and so forth. Those were, in fact, made.

The commitment really is, I think, a matter of providing the funding and providing the long-term stability to see a program through.

A commitment to fusion does become a little more difficult because it is a long-range program. For that reason I thought the Magnetic Fusion Energy Engineering Act of 1980 handled it very nicely. An FED was included, with a 10-year commitment. That does set a requirement.

Dr. KUMMER. If a national commitment means the kind of commitment we had on the Apollo program, then I would think we should not wait to embark on FED until we have a national com-

mitment, because we may or may not get that, and be ready to embark on FED and we ought to proceed in that direction.

The defense programs do not really have a national commitment like the Apollo program had a national commitment. What they do have is a continuity within the procuring agents and in the programs like the space programs and energy programs today, we do not have that same continuity. Therefore, maybe a national commitment becomes more important.

Dr. ANTHONY. If you are looking for a simple answer, get the White House to issue a statement that this is a national program.

Mr. SCHOLL. A true national commitment would start with a Presidential statement that fusion is our long-term domestic inexhaustible energy resource, followed by a congressional commitment of a multiyear authorization and appropriation of significant funding. This would be followed by a very strong management structure and organization built up within the Department of Energy to effectively manage the program and get the public information out required to maintain the momentum for such a program.

Mr. REICHLE. Are there further comments or questions from the panel? If not, let me say that the panel plans to get together tonight for dinner to consider the views expressed during the day, together with any other thoughts panel members may have. We shall submit out thoughts to Congresswoman Bouquard.

In the meantime, I will take a stab at trying to summarize the day and, if I do it inaccurately, I will hear about it at dinner, you can be sure.

In general, the people who testified are in agreement that there is a need for fusion and its development.

I believe there is general agreement that fusion is ready to proceed into an engineering stage of development, and that this must be done in such a way as continually to involve the national laboratories who have been so important in fusion's first stage of development and who are also important in its next stage of development.

I think there is general agreement that there should be an FED and a CFE, and that they should lead to civilian power.

There seems to be agreement that, if we have a CFE, it should be industrially managed and should focus upon the mission of civilian electric power, even though that there are other ways in which fusion can be applied. Such a well-defined mission would provide a focus. But, that is not enough. We need a national commitment. How we get such a commitment is uncertain, but having it would be significant in buoying fusion up and moving ahead.

So, if there are no other comments or questions from the panel or the presenters, the meeting is adjourned.

[Whereupon, at 4:30 p.m. the Panel was adjourned.]

APPENDIX

ADDITIONAL MATERIAL SUBMITTED FOR THE RECORD

EBASCO SERVICES INCORPORATED

EBASCO

Two World Trade Center New York, N.Y. 10048

Leonard F. C. Reichle
Executive Vice President

July 27, 1981

Mrs Marilyn L Bouquard, Chairman
Subcommittee on Energy Research
and Production
Committee on Science and Technology
U S House of Representatives
Washington, D.C. 20515

Dear Mrs Bouquard:

Your Advisory Panel on Fusion Energy held hearings in Room 2325 of the Rayburn Building during the afternoon of June 29, 1981. Witnesses identified on Attachment A presented their views and responded to questions of Panel members who participated in the hearings (see Attachment B).

In general, it was the consensus of witnesses presenting testimony that:

- 1 - Fusion energy is needed as a future electric energy option.
- 2 - The fusion program is ready now to move into the engineering phase of development. The Advisory Panel's views confirm the conclusions of the 1980 Fusion Advisory Panel, the Buchsbaum Report, and the action of the 96th Congress in enacting the Magnetic Fusion Energy Engineering Act of 1980 (PL 96-386).
- 3 - The fusion program should be goal-oriented. The goals set-forth in PL 96-386; i.e., construction of a device for the demonstration of the engineering feasibility by 1990 and of a magnetic fusion demonstration plant by the turn of the 21st Century are reasonable and should be pursued aggressively.
- 4 - A national commitment to the development of magnetic confinement fusion is essential to the accomplishment of the goals of PL 96-386.
- 5 - The best way to implement the next phase of the national fusion energy program is to establish and fund a center for Fusion Engineering (CFE) with responsibility for getting a Fusion Engineering Device (FED) built, for having supporting R&D performed, and for planning and programming a Fusion Demonstration Plant (FDP) around the turn of the century.

- 2 -

Mrs Marilyn L Bouquard, Chairman

- 6 - Management and technical direction by industry, with meaningful involvement by the major laboratories, will give the CFE the highest probability of successfully carrying-out its mission.
- 7 - The Department of Energy (DOE) promptly should issue a Request for Proposal (RFP) for management and technical direction of the CFE, and select the best competitively on the basis of qualifications and relevant experience.

Discussion among Advisory Panel members attending our evening dinner meeting (see Attachment C) arrived at the following conclusions, partly by listening to testimony presented during the afternoon and partly on the basis of Panel members' knowledge and interaction:

- 1 - The Advisory Panel reaffirms the validity of the goals, objectives and timeliness of the Magnetic Fusion Energy Engineering Act of 1980.
- 2 - A way should be found to get the new Administration, hopefully the President himself, to declare a national commitment to the development of fusion energy for civilian electric power.
- 3 - The CFE and the FED should be "tied together". The CFE should assume immediate responsibility for the FED conceptual design. The primary missions of the CFE should be to get the FED designed and built, to program and to get accomplished an appropriate technology R&D effort to meet the immediate and longer-term needs of the FED and FDP. The CFE should not become "another national laboratory". The CFE should expand our technical data base. It should take over the work of the Technical Management Board, which is directed toward a FED.
- 4 - The state-of-the-art is now such that vigorous programs of technology R&D and plasma optimization will lead to a successful FED. The scope of the FED must be determined by the technical R&D requirements of an overall plan leading to the FDP - rather than by some arbitrary design restriction, such as a \$1 billion dollar ceiling. The FED should be a tokamak.

- 3 -

Mrs Marilyn L Bouquard, Chairman

- 5 - The Panel members agreed that there exists several valid models for the management and technical direction of the CFE. A majority of the Panel favored industrial management with strong involvement of the present fusion community.

The recommendations of the Advisory Panel are:

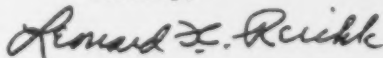
- 1 - The Secretary of Energy should be requested to prepare a mission statement for the Center for Fusion Engineering (CFE) and a plan for its implementation, consistent with the aims of the Magnetic Fusion Energy Engineering Act of 1980. The mission statement should include construction of a Fusion Engineering Device (FED) and should emphasize the goal of achieving a Fusion Demonstration Plant around the turn of the century.
- 2 - The Subcommittee on Energy Research and Production should hold hearings: (a) inviting the DOE to state its near-term plans for implementing the Magnetic Fusion Engineering Act, and (b) inviting industry, laboratories and universities involved in fusion, and others to comment on these plans.

As an Advisory Panel, we shall be happy to meet again whenever it might be helpful to you.

I look forward to discussing the matter with you at your convenience.

Best wishes!

Sincerely,



LFCR:pf

cc: Advisory Panel Members

Attachments: Copies of Panel Members' Comments on Draft Letter

ATTACHMENT AFUSION ADVISORY PANEL MEETING

Dr Harold Agnew, President
General Atomic Company
LaJolla, California

Dr Don Anthony, Manager
Fusion Energy Systems
General Electric Company
Schenectady, New York

Dr Stephen O Dean, President
Fusion Power Associates
Gaithersburg, Maryland

Dr Donald Kummer, Manager
Fusion Energy
McDonnell-Douglas Company
St Louis, Missouri

Mr Sidney Law, Director
of Research
Northeast Utilities
Hartford, Connecticut
(representing the Atomic
Industrial Forum Committee
on Fusion)

Mr Frederick Maxwell, President
Boeing Engineering & Construction
Company
Seattle, Washington

Mr Lawrence Mead
Sr Vice President, Engineering
Grumman Aerospace Corporation
Bethpage, New York

Mr Martin Schoil
Associate Technical Director
Energy and Resources Division
MITRE Corporation/Metrek Division
McLean, Virginia

Mr R J Sherman, Chairman
of the Board
Ebasco Services, Inc.
New York, New York

Dr Peter Staudhammer, Laboratory
Manager, Nuclear Energy
TRW Company
Redondo Beach, California

ATTACHMENT B

MEMBERS OF THE

ADVISORY PANEL ON FUSION ENERGY

Attending Hearings on June 29, 1981

Mr Calvin J Blattner
Vice President Engineering
McDonnell Douglas Astronautics Co.
P O Box 516
St Louis, MO. 63166
314/232-5757

Dr John W Landis
Senior Vice President
Stone & Webster Engineering Corp.
P O Box 2325
Boston, Massachusetts 02107
617/973-0611

Dr Brian Cairns
Manager, Advanced Technology
Boeing Aerospace
P O Box 3999 (Mail Stop 84-05)
Seattle, Washington 98124
206/773-1620

Mr Mike McCormack
Energy Consultant
508 A Street, S.E.
Washington, D. C. 20003
202/544-0254

Dr Ronald C Davidson
Director, Plasma Fusion Center
Massachusetts Avenue
Cambridge, Massachusetts 02139
617/253-8102

Dr Tihiro Ohkawa
Vice President and Director
Fusion Division
General Atomic Company
P O Box 81608
San Diego, California 92138
714/455-3111

Dr Ersel Evans
Vice President
Westinghouse Hanford Company
Box 1980
Richland, Washington 99352
509/376-4896

Mr Leonard F C Reichle
Executive Vice President
EBASCO Services, Inc.
Two World Trade Center
New York, N. Y. 10048
212/839-2800

Dr T Kenneth Fowler
Associate Director for CTR
University of California
Lawrence Livermore Laboratory
P O Box 808
Livermore, California 94550
415/422-9862

Dr Murray Rosenthal
Associate Director for Advanced
Energy Systems
Oak Ridge National Laboratory
P O Box X
Oak Ridge, Tennessee 37830
615/574-4322

Dr Harold Furth
Director, Princeton Plasma Physics Lab.
Princeton University
P O Box 451
Princeton, New Jersey 08540
609/683-3555

Mr Dwain F Spencer
Director
Advanced Power Systems Division
Electric Power Research Inst.
P O Box 10412
Palo Alto, California 94303
415/855-2498

ATTACHMENT "C"ATTENDED EVENING DINNER MEETING

Mr. Calvin J Blattner
Vice President Engineering
McDonnell Douglas Astronautics Co.
P. O. Box 516
St. Louis, Missouri 63166

Mr. Mike McCormack
Energy Consultant
508 A Street, S. E.
Washington, D. C. 20003

Mr. Ronald C Davidson
Director, Plasma Fusion Center
Massachusetts Institute of
Technology
77 Massachusetts Avenue
Cambridge, Massachusetts 02139

Mr. Leonard F C Reichle
Executive Vice President
Ebasco Services Inc.
Two World Trade Center
New York, N. Y. 10048

Dr. Ersel Evans
Vice President
Westinghouse Hanford Company
Box 1970
Richland, Washington 99352

Dr. T Kenneth Fowler
Associate Director for CTR
University of California
Lawrence Livermore Laboratory
P. O. Box 808
Livermore, California 94550

Dr. Harold Furth
Director, Princeton Plasma
Physics Laboratory
Princeton University
P. O. Box 451
Princeton, New Jersey 08540

Dr. Brian Cairns
Manager, Advanced Technology
Boeing Aerospace
P. O. Box 3999 (Mail Stop 84-05)
Seattle, Washington 98124

Dr. Murray Rosenthal
Associate Director for Advanced
Energy Systems
Oak Ridge National Laboratory
P O Box X
Oak Ridge, Tennessee 37830

AGENDA
FUSION ADVISORY PANEL
29 June 1981
Room 2325 Rayburn

- 12:30 p.m. Welcome - Len Reichle, Chairman
- 12:45 p.m. Presentation (Panel #1)
 Fusion Power Associates
 Atomic Industrial Forum
- 1:30 p.m. Presentations (Panel #2)
 General Atomics Company
 Boeing Engineering and Construction Company
 Ebasco Services Company
 Grumman Aerospace Corporation
- 3:00 p.m. Presentations (Panel #3)
 McDonnell-Douglas Astronautics Company
 TRW
 General Electric Company
 MITRE
- 4:30 p.m. Summation and Adjourn - Len Reichle, Chairman

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, D.C. 20515

FUSION ADVISORY PANEL MEETING

June 29, 1981
Room 2325 Rayburn, 12:30 p.m.

Panel #1

Dr. Stephen O. Dean, President
Fusion Power Associates
Gaithersburg, Maryland

Mr. Sidney Law, Director
of Research
Northeast Utilities
Hartford, Connecticut
(representing the Atomic
Industrial Forum Committee
on Fusion)

Panel #2

Dr. Harold Agnew, President
General Atomic Company
La Jolla, California

Mr. R. J. Sherman, Chairman
of the Board
EBASCO Services, Inc.
New York, New York

Mr. Frederick Maxwell, President
Boeing Engineering & Construction Co.
Seattle, Washington

Mr. Lawrence Mead
Sr. Vice President, Engineering
Grumman Aerospace Corporation
Bethpage, New York

Panel #3

Dr. Donald Kummer, Manager
Fusion Energy
McDonnell-Douglas Company
St. Louis, Missouri

Dr. Don Anthony, Manager
Fusion Energy Systems
General Electric Company
Schenectady, New York

Dr. Peter Staudhammer, Laboratory Mgr.
Nuclear Energy
TRW Company
Redondo Beach, California

Mr. Martin Scholl
Associate Technical Director
Energy and Resources Division
MITRE Corporation/Metrek Division
McLean, Virginia

MEMBERSHIP OF THE
ADVISORY PANEL ON FUSION ENERGY

Mr. Calvin J. Blattner
Vice President Engineering
McDonnell Douglas Astronautics Co.
P. O. Box 516
St. Louis, MO. 63166

Dr. Robert Conn
Chemical, Nuclear and Thermal
Engineering Department
School of Engineering & Applied Sciences
University of California - Los Angeles
6291C Boelter Hall
Los Angeles, California 90024

Dr. Ronald C. Davidson
Director, Plasma Fusion Center
Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, Massachusetts 02139

Dr. Ersel Evans
Vice President
Westinghouse Hanford Company
Box 1970
Richland, Washington 99352

Dr. T. Kenneth Fowler
Associate Director for CTR
University of California
Lawrence Livermore Laboratory
P. O. Box 808
Livermore, California 94550

Dr. Harold Furth
Director, Princeton Plasma Physics Laboratory
Princeton University
P. O. Box 451
Princeton, New Jersey 08540

Mr. Joseph G. Gavin, Jr.
President
Grumman Corporation
Bethpage, New York 11714

*Chairman

Mr. Mike McCormack
Energy Consultant
508 A Street, S.E.
Washington, D. C. 20003

Mr. Henry K. Hebel
President
Boeing Aerospace
P. O. Box 3999 (Mail Stop 84-05)
Seattle, Washington 98124

Dr. John W. Landis
Senior Vice President
Stone & Webster Engineering Corp.
P. O. Box 2325
Boston, Massachusetts 02107

Dr. Tihiro Ohkawa
Vice President and Director
Fusion Division
General Atomic Company
P. O. Box 81608
San Diego, California 92138

Mr. Leonard F. C. Reichle*
Executive Vice President
EBASCO Services Inc.
Two World Trade Center
New York, N. Y. 10048

Dr. Murray Rosenthal
Associate Director for Advanced
Energy Systems
Oak Ridge National Laboratory
P. O. Box X
Oak Ridge, Tennessee 37830

Mr. Robert I. Smith
Chairman of the Board
Public Service Electric & Gas Co.
80 Park Place
Newark, New Jersey 07101

Mr. Dwain F. Spencer
Director
Advanced Power Systems Division
Electric Power Research Inst.
P. O. Box 10412
Palo Alto, California 94303

NEWS from:**Committee on Science and Technology****U.S. House of Representatives****DON FUQUA**
Chairman**LARRY WINN, Jr.**
Ranking Minority Member

#97-72

June 29, 1981

FCR IMMEDIATE RELEASE

**BOUQUARD CONVENES FUSION ADVISORY PANEL
TO "FAST TRACK" FUSION ENGINEERING CENTER**

"The taxpayer can be saved over \$2 billion 1980 dollars if the Department of Energy will stop dragging its feet and move now into the engineering phase of fusion energy development", declared Representative Marilyn L. Bouquard (D-TN), who chairs the Energy Research and Production Subcommittee of the House Committee on Science and Technology. "To accomplish this one needs to move quickly, involve industry in both the technical and management phase of the program development, and maintain a strong and viable research program", she said.

To study the feasibility of "fast tracking" the fusion program and, in particular, establishing a major Fusion Engineering Center, Mrs. Bouquard has convened the Subcommittee's prestigious Fusion Advisory Panel. The Panel will meet on Monday, June 29, 1981, at 12:30 p.m. in Room 2325 of the Rayburn House Office Building. The Panel will receive presentations from senior executives and managers of ten different companies, professional organizations, and not-for-profit corporations. A list of presentors is included below.

Congresswoman Bouquard noted that "The Fusion Center can be the most important link to industrial involvement in fusion, and without industry the U.S. will not have fusion energy."

The Fusion Advisory Panel was established in the 96th Congress and was formerly chaired by Dr. Robert Hirsch of the Exxon Research Corporation. Its new Chairman is Mr. Leonard Reichle, Executive Vice President, EBASCO Services, Inc., New York, New York. Mr. Reichle along with Mr. Calvin Blattner (Vice President - Engineering, McDonnell-Douglas Astronautics), Dr. Murray Rosenthal (Associate Director, Oak Ridge National Lab), and the Honorable Mike McCormack (former Member of Congress and past Chairman of the Subcommittee on Energy Research and Production) will be new members on the Panel.

Presentors:

Dr. Stephen O. Dean, President, Fusion Power Associates
Mr. Sidney Law, Director of Research, Northeast Utilities
Dr. Harold Agnew, President, General Atomic Company
Mr. Frederick Maxwell, President, Boeing Engineering & Construction Co.
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Staff Contact: Dr. Allan Mense
202/225-3472